PART TWO STUDIES

SUMMARIES AND EXCERPTS

July 15, 1984

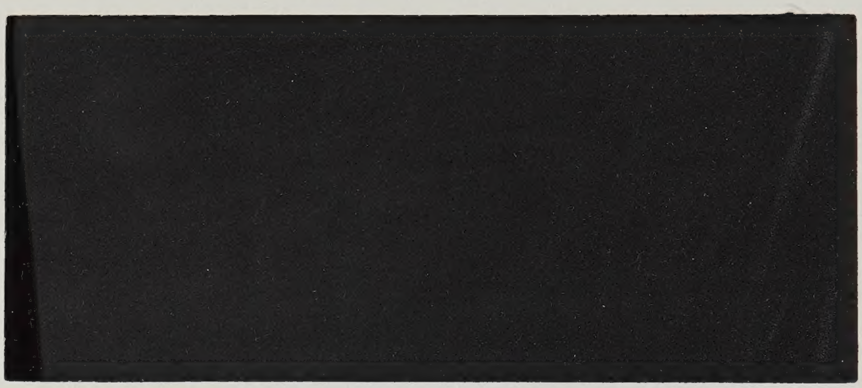
OMS
7/28

Royal Commission on the *Ocean Ranger* Marine Disaster

Canada

Commission Royale sur le Désastre Marin de l'*Ocean Ranger*

Newfoundland/Terre-Neuve



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INTRODUCTION

The Royal Commission on the Ocean Ranger Marine Disaster has been given comprehensive Terms of Reference which are divided into two parts.

Part One calls for an extensive investigation into the loss of the drill rig, Ocean Ranger. This inquiry has been underway since the Commission was jointly established in March 1982 by the governments of Canada and Newfoundland and Labrador.

Part Two of the Commission's Terms of Reference call for it to "inquire into, report upon, and make recommendations with respect to" both the marine and drilling aspects of practices and procedures in respect of Eastern Canadian Offshore drilling operations and to a number of specific matters relating to drilling units operating offshore.

To address the Part Two Terms of Reference, the Commission has identified as its objective:

TO IDENTIFY PRACTICAL MEANS OF IMPROVING THE SAFETY OF EASTERN CANADA OFFSHORE DRILLING OPERATIONS.

The study area is Eastern Canadian Offshore (see illustration) extending from the shoreline to the limits of jurisdictional claims. The area extends from the Canada-US boundary north to the limit of areas which will be serviced from East Coast ports and use marine drilling systems (approximately 75°N).

The subject of study is offshore exploration and delineation drilling operations, including service and supply (marine and air) activities

The issue is human safety. Property safety will be considered to the extent it affects human safety. Environmental safety will be addressed by a State of the Art Review.

The Royal Commission, as part of its information gathering process has funded a number of studies, most of which are state of the art reviews. Most of these studies are now in draft or final form and this document contains the Executive Summaries or other relevant extracts from these reports. This material is intended to provide background to participants at the Conference on Safety Offshore Eastern Canada to be held in St. John's, Newfoundland August 21-23, 1984 and hosted by the Royal Commission.

Readers are cautioned that several of these studies are still in draft form and subject to amendment by the authors as review comments are received. For example, the Canadian Petroleum Association is providing review comments on several of the reports dealing with the physical environment.

Readers are further asked to note that, while these reports are the property of the Royal Commission on the Ocean Ranger Marine Disaster, and the contents should be treated as confidential where material is still in draft form, the opinions, conclusions and recommendations are those of the authors. Acceptance of these reports by the Royal Commission is for contractual purposes only and should not be construed as acceptance of any of the opinions, conclusions or recommendations contained therein.

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Director of Studies
15 July, 1984

DRAFT

A REVIEW OF ICE INFORMATION FOR OFFSHORE EASTERN CANADA

Contract No. OSC83-00030

Submitted to: Royal Commission on the Ocean Ranger Marine Disaster

Submitted by: NORDCO Ltd.

File Ref.: 122-83G

Date: JUNE 1984

A REVIEW OF ICE INFORMATION FOR OFFSHORE EASTERN CANADA

EXECUTIVE SUMMARY

The objective of the study undertaken by NORDCO Limited with the assistance from the Centre for Cold Ocean Resource Engineering and the Memorial University of Newfoundland is to critically assess the adequacy of available information on floating ice and structural icing as input to design criteria, operational procedures, and emergency response planning for eastern Canadian offshore exploratory drilling. The study also examines the adequacy of ice hazard detection systems required for safe conduct of drilling operations in the area. The region encompassed by the study extends from the U.S.-Canada border in the south, to the northern limit of the area serviced by east coast ports and where marine drilling systems are used (approximately Lancaster Sound at 75°N). When assessing the adequacy of the ice information, the underlying issue is always human safety.

Icebergs are a significant factor in exploratory operations from the Grand Banks east of Newfoundland, to the northern limit of the study area. The data bases for flux, dimensions, mass, velocity and mechanical properties of icebergs are generally inadequate for definition of extreme events. Operational techniques have been developed that permit exploratory drilling using either dynamically positioned or anchored platforms in the presence of icebergs. These techniques are generally adequate, but improvements are required in the detection of small pieces of ice, both in terms of increased range and for tracking targets through sea clutter in the vicinity of the drilling platform.

The most significant effect of sea ice on exploratory drilling activity in the study area is to limit the operating season. Drilling is currently taking place in two areas where sea ice might be a problem: the Grand Banks during the winter season; and off Labrador during the early part of the summer. Detection of isolated floes under adverse weather conditions is likely to be a problem. However,

information on the mechanical properties of ice under such conditions is sparse, so estimating possible damage to a vessel or drilling platform is difficult.

The data bases for ice loadings due to freezing sea spray and for atmospheric icing conditions (freezing precipitation, supercooled fog, and wet snow turning to ice) is inadequate for calculation of extreme events. The formation and rate of build-up of sea spray ice is a function of vessel shape and size, the shape of the structural members exposed to icing, the nature of the surface coating, and the heat flow through the surface. Although empirical and theoretical models have been developed for the prediction of sea spray icing on vessels, there is very little data on ice accumulation on semi-submersibles. From studies for the Hibernia and Sable Island areas, typical ice loads for such vessels with a 50 year return period may be in the order of 550 tonnes for sea spray icing, with an additional 300 tonnes from atmospheric sources.

Fog and adverse weather conditions are common throughout the east coast exploratory drilling season. Therefore, all weather, day/night ice detection systems are essential from the Grand Banks northwards. Radar is the commonest sensor, but it is evident that floating ice is a poor target, and small pieces of ice cannot be reliably detected using conventional marine radars except under ideal propogation conditions. On-going R & D suggests there is room for improvement in marine radar performance. Airborne ice reconnaissance is often restricted by poor visibility. Imaging airborne radars have proved successful in detecting areas of pack ice, but less so in locating and identifying isolated floes or small icebergs.

Design and construction standards for vessels operating in ice infested waters have been developed by the Classification Societies largely for insurance purposes, and more recently, through the Arctic Shipping Pollution Prevention Regulations. In 1983, Interim Standards for the design, construction and operation of mobile offshore drilling units (MODU's) were issued by the Canadian Coast Guard. However, up to now all exploratory drilling has been restricted to open water

conditions - the only exception being the use of supply vessels for iceberg towing or deflection. Ice management procedures developed in the early 1970's have now become accepted practice and are part of the COGLA guidelines for exploratory drilling.

Several European countries have developed MODU designs for severe weather operations. These designs emphasise covered work areas and, in some cases, flush surfaces to minimise ice accretion. Several of the designs claim to be "ice strengthened", but in the absence of large scale ice impact data, it is difficult to assess the actual capability of such vessels. From the information obtained by the study team, very little attention seems to have been given to the operation of exposed emergency equipment, such as lifeboats, under icing conditions.

Each of the chapters dealing with icebergs, sea ice, icing, ice detection, and the regulatory environment, and with an assessment of the current state of knowledge. These assessments are reproduced below.

Icebergs

(i) Icebergs are a significant factor in exploratory drilling operations from the Grand Banks east of Newfoundland northwards. Although icebergs have been observed in the Gulf of St. Lawrence, they are not considered a serious impediment to drilling in the area. Similarly, south of Newfoundland and off Nova Scotia, icebergs are so rare they are unlikely to interrupt drilling operations.

(ii) The iceberg "season" extends from January to July on the Grand Banks, with the maximum flux occuring in April or May. Further north icebergs occur year round. The minimum flux of icebergs in all areas is between October and December.

(iii) The data bases for flux, dimensions, mass, velocity and mechanical properties are generally inadequate for definition of

extreme events. The best available data bases are for the Grand Banks south of 48°N and the Labrador continental shelf. However, due to difficulties in detecting small bergs the data bases for these areas may be biased towards icebergs larger than 1,000 tonnes. Information on mechanical properties is inadequate everywhere.

(iv) Operational techniques have been developed that permit exploratory drilling using either dynamically positioned or anchored platforms in the presence of icebergs. These techniques are generally adequate, but improvements are required in the detection of small pieces of ice, both in terms of increased range and for tracking through sea clutter in the vicinity of the drilling platform. The early detection of icebergs representing a hazard to anchored platforms, is essential to their safe operation as lead times for moving such platforms is significantly greater than for the dynamically positioned systems.

(v) Research on the impact forces between icebergs of various sizes and exploratory drilling platforms, particularly as might occur with severe sea states is in its infancy. Progress is hampered by lack of knowledge of the maximum velocities small pieces of ice might attain, mechanical properties of the ice, and its behaviour in impact situations.

(vi) The presence of isolated growlers can present a hazard to supply vessels, particularly if the vessel is moving at its normal cruising speed on the assumption of ice free conditions. Ice strengthened vessels are generally used from the Grand Banks north, but the degree of strengthening is unlikely to be sufficient to ensure the safety of the vessel if it is travelling at high speed at the moment of impact. Neither radar nor visual detection of growlers is reliable under the prevailing weather and sea conditions off the east coast.

Sea Ice

(i) The most significant effect of sea ice on current drilling activity within the study area is to limit the drilling season.

(ii) Current operating procedures call for the drilling unit to move off location if sea ice is threatening.

(iii) Drilling is currently taking place in two areas where sea ice is likely to be a problem. These areas are the Grand Banks in winter and off the Labrador coast in the early summer.

(iv) The two situations identified where the danger from sea ice would be the greatest are: (a) collision with an isolated floe drifting ahead of the main pack during a storm situation and (b) sea ice drifting into the drilling area in a situation when the unit could not move off site.

(v) There is insufficient data available to define the risks associated with (iv).

(vi) The data base for many sea ice parameters is not sufficient to define the effects of an impact.

Icing

(i) The database on ice loadings from sea spray is limited and does not permit the accurate calculation of "100 year events".

(ii) Empirical and theoretical models have been developed for the prediction of sea spray icing on vessels, but comparisons suggest that results reflect the type of vessel studied in the particular database and are not transferable to significantly different types of vessel.

(iii) Using an empirical formula plus environmental data, the occurrence of moderate or severe sea spray icing conditions is

estimated to occur 8% of the time for the Sable Island area and 9.5% to 12.5% at Hibernia during the most severe month - February in both cases. Only general information in the form of maps appears to be available outside these two areas.

(iv) Formation and rate of build-up of sea spray ice is a function of vessel shape and size, the shape of structural members exposed to icing, the nature of the surface coating, and the heat flow through the surface. Therefore, most regulatory authorities give no guidance on ice build-up and limit themselves to specifying the maximum allowable ice accumulation to be used in stability calculations.

(v) Icing data for semi-submersibles is virtually non-existant, and there is no clear understanding of ice accumulation on the underside of deck areas, or on changes in accumulation rates up the sides of vertical or inclined columns.

(vi) The database for atmospheric icing events (freezing precipitation, supercooled fog, and wet snow turning to ice) is not sufficient to calculate meaningful "100 year events".

(vii) There are indications that for some areas the accumulation of ice on drilling platforms due to freezing precipitation may be as important as the accumulation from sea spray.

(viii) Some of the operating manuals reviewed in the course of this study make no reference to icing of any type, whereas others detail actions to be taken, including load dumping priorities.

(ix) Total icing loads with a 50 year return period in the Hibernia area have been estimated to be 550 tonnes from sea spray icing, with a maximum load, taking into account atmospheric icing, of about 830 tonnes. However, these values depend heavily on a number of rig parameters and the model used to estimate extent and rate of accumulation of ice.

(x) A formal record of ice build-up on drilling platforms at different locations and operating under different environmental conditions is urgently required.

Ice Detection

(a) Icebergs

(i) Icebergs of any size are poor radar targets.

(ii) The presence of clutter, especially sea clutter, is the major limiting factor in the detection of icebergs when at ranges shorter than the maximum. This presents a serious problem in the detection of bergy bits and, in particular, growlers, as they are normally only detected at short ranges, and even in low to moderate sea states the clutter may be sufficient to mask them at their maximum ranges.

(iii) In the absence of clutter there is a direct relationship between the size of the iceberg and the maximum range of detection. The tremendous scatter in the range of detection data provided by the various researchers suggests that caution is necessary in applying the relationship.

(iv) Subnormal propagation conditions dominate in the Grand Banks region. There is very little information available regarding the conditions in the more northern areas. There is a need for more quantitative information for all areas.

(v) The level of on-going R&D indicates there is recognition of the need for improvement in marine radar for the detection of icebergs.

(vi) None of the research reported here provided significant information on the number of icebergs not detected at all on marine radar. This has created the false impression that only small targets in clutter go undetected. However, it has been the

experience of marine interests in these waters that quite frequently icebergs of almost any size and at moderate ranges do go undetected. This is difficult to quantify but the need exists to determine the percentage of time and the conditions under which this situation might occur.

(vii) Given the predominately poor visibility conditions, particularly on the Grand Banks, there is some question regarding the effectiveness of airborne visual reconnaissance.

(viii) Long range visual reconnaissance by surface vessels will also be restricted by the poor visibility and the short coverage area observed at any given time.

(ix) The effectiveness of short range visual reconnaissance by support vessels in the vicinity of a drilling platform at times of low visibility or in darkness is unknown. Larger ice targets may be detected but growlers may still not be sighted under these conditions. During rough sea conditions the movements of the support vessel may be restricted, reducing its capability to perform reconnaissance work when it is most needed.

(x) SLAR, because of its all weather, day/night capability, has the potential of being a very valuable reconnaissance tool, but there is considerable confusion regarding its true detection capability against essentially point targets. As with marine radar this capability needs to be quantified.

(xi) A major limitation with SLAR is the problem of identifying targets. In areas such as the Grand Banks there is significant fishing and marine transport traffic. Thus, the probability of false alarm is significant, at least in this region.

(b) Sea Ice

(i) The detection range for sea ice floes appears to be similar to that for small icebergs and growlers. Signal processing techniques and high antenna heights have been shown to improve topographic feature detection ranges for consolidated pack ice in the Beaufort Sea, but this may not apply for the East Coast of Canada.

(ii) Because unconsolidated or loose pack ice may take on the appearance of sea clutter on marine radar it may be difficult to detect under certain conditions.

(iii) The inability to identify ice types in the sea ice pack using marine radar may prevent detection of potential dangerous multi-year floes.

(iv) Because pack ice is generally a large scale phenomena, visual observations, either from ship or aircraft, should be adequate for monitoring it, and poor visibility should not present a major problem. The detection of multi-year floes should also be possible but well trained observers will be required.

(v) The almost all weather day/night reconnaissance capability of SLAR makes it an ideal instrument for the reconnaissance of sea ice. It is also capable of providing classification of ice types and accurate positional information.

(c) General Considerations

(i) Individually, each detection method has its shortcomings. The performance achieved through an integration of all the techniques may be adequate but there is insufficient evidence to make an accurate quantitative assessment. For long range strategic reconnaissance upstream of a drill site, it would appear that the combination of both airborne and ship based visual reconnaissance along with SLAR might be adequate. However, SLAR would have to be

employed on a dedicated basis rather than as a tool of opportunity employed by another agency. With the integration of all these methods, however, small and dangerous targets may still slip through undetected.

ii) For short range close tactical monitoring there are a number of problems. Under moderate sea conditions, with even moderate to poor visibility in daylight, the combined use of marine radar and diligent visual reconnaissance (from the drilling platform and service vessels) should make it possible to detect and keep track of all ice hazards. Under severe low visibility weather conditions and in darkness, visual reconnaissance will be impossible. Marine radar will have to be relied upon almost totally. Unfortunately, marine radar is least reliable under severe weather conditions and ice hazards may approach undetected. As noted earlier, it should be relatively easy to track sea ice and this is applicable even at short ranges from the drilling platform. The problem at close range is that small icebergs, growlers, multi-year floes, etc., within the sea ice pack may go undetected when reliable detection and precise positional information is most necessary. The presence of darkness, low visibility and/or rough seas will compound this problem.

Regulations

(i) Design and construction standards for vessels operating in ice infested waters have been developed by Classification Societies, largely for insurance purposes. The Arctic voyage of the "Manhattan" in 1969 was closely followed by promulgation of the Arctic Waters Pollution Prevention Act, and the accompanying Arctic Shipping Pollution Prevention Regulations. These regulations, for the first time, specified the design and construction standards required for vessels operating north of 60°N latitude within 100 miles of the Canadian coastline. These regulations apply to exploration activity north of 60°N latitude - including the dates of entry and exit from these waters for

different ice class vessels. The design regulations do not specifically refer to MODU's.

(ii) The Interim Standards for the design, construction and operation of MODU's recently issued by the Canadian Coast Guard, generally require ice loadings to be calculated for 100 year return events. However, as is evident from this study, there is not sufficient information on most ice parameters to calculate realistic 100 year events.

(iii) All exploratory drilling vessels operating in the vicinity of floating ice have sophisticated ice management systems, with clearly defined operating procedures should approaching ice pose a hazard to the operations. However, these management systems rely on detection of hazardous ice and it is doubtful whether present technology is adequate for detection of small bergy bits and growlers under adverse weather conditions.

(iv) A number of theoretical studies have been carried out in order to estimate the damage a small, undetected piece of ice is likely to inflict on a MODU. Recent laboratory experiments indicate the energies involved may be significantly greater than those assumed by Classification Societies for supply boat collision with a MODU. However, the collision forces are dependent on the behaviour of the ice on impact and there have been no large scale experiments to verify the theoretical assumptions. Such experiments are needed to determine damaged stability requirements for MODU's, as well as strengthening requirements when contact with floating ice is likely to be a common occurrence.

(v) Several European countries have MODU designs for severe weather operations. The advantages of such vessels are flush surfaces to minimize structural icing and covered work and emergency assembly areas. Several of these designs have "ice strengthening", but it is not clear how effective such re-inforcing would be in the event of a collision with glacial ice.

(vi) Very little consideration appear to have been given to the operation of exposed emergency equipment, such as lifeboats and liferafts, under freezing spray or precipitation conditions. Also, it is not clear from regulations whether lifeboats or liferafts could operate in loose pack ice without a significant risk of hull puncture.

A REVIEW OF THE STATE-OF-THE-ART IN MARINE CLIMATOLOGY ON THE EAST COAST OF CANADA

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EXECUTIVE SUMMARY

The objective of this two-part report is to provide a state-of-the-art review of marine climatology off the east coast of Canada. This has been prepared in support of the Royal Commission on the Ocean Ranger Marine Disaster. The report's terms of reference are specified in Appendix A. The focus of this report is human safety in offshore exploratory drilling and support activities.

Part I describes the hazards to human safety posed by the atmosphere. In addition, a review of research activities related to marine climatology to date, and the agencies involved, is presented. Finally, deficiencies in knowledge are identified.

Part II describes meteorological observing and analysis techniques for the identified parameters, and describes in detail the deficiencies in the present state of knowledge of marine climatology. Recommendations are made to improve the understanding of the marine environment, as related to human safety in offshore exploration activities.

This report deals only with atmospheric parameters; waves, ice and oceanography will be addressed in separate reports.

PART I

The climatology of atmospheric parameters is very important to the design of structures and operating systems for offshore exploration. Using historical data, it is possible to quantify the risks to human safety posed by the atmosphere.

Of all atmospheric parameters, wind has the greatest potential for risk to human safety. The wind may exert considerable force on a structure, and create dangerous working conditions for personnel on exposed decks. Wind is also the major forcing factor in generating waves, currents and freezing spray.

Ice accretion is a major hazard to drill rigs, supply vessels and particularly helicopters. Icing may occur due to freezing spray, freezing precipitation or rime or clear ice in cloud. The stability of rigs and ships may be adversely affected by large amounts of accreted ice. In addition, working conditions will be hazardous due to slippery decks. Helicopter operation is extremely dangerous in icing conditions, due to sudden ice-induced engine failure and icing of rotor blades, causing loss of control and higher stall speeds. Helicopters may be affected by any of the three types of icing.

The presence of low cloud ceilings and reduced visibilities make flying dangerous. Specific operating limits are required for take-off and landing and visual flight rules (VFR) travel enroute. Reduced visibility may also contribute to collisions between supply vessels, drill rigs and icebergs.

Hazards to human safety may occur due to extremely cold air temperatures and windchill. Survival time for personnel in the water is greatly reduced for cold sea temperatures. In addition, hazards can occur due to lightning strikes, particularly on aircraft, turbulence in the wind field, high humidity and salt content, which may affect sensitive electronic equipment, and inadequate drainage for heavy rainfall rates.

A brief description of the climatology of marine areas off the east coast of Canada, highlighting the critical parameters, can be found in Appendix B.

The majority of work in marine climatology in Canada is done by the Atmospheric Environment Service (AES) of the federal Department of Environment. The AES participates in data collection, quality control and archiving, and in instrument development, as well as provision of climate information and expertise, and applied climate research.

Oil industry activities related to climate largely parallel those of government, in data acquisition, archiving and system development. However, many industry studies are site-specific and proprietary. Also, the main thrust of work to date has been concentrated on parameters outside the scope of this report, such as waves and sea ice.

Other agencies have contributed to the knowledge of marine climatology, particularly for wind. These include the Bedford Institute of Oceanography and the Marine Environmental Data Service, both of the federal Department of Fisheries and Oceans, and the United States Army and Navy.

A survey of literature on atmospheric parameters reveals that considerable work has been done on various aspects of wind, icing, sea surface temperature and storms. However, much of the work has been peripheral to requirements related to marine climatology. For example, much of the work on wind fields is directed towards wave hindcasting. Icing research has been concentrated on theoretical concerns. Other parameters have been largely ignored.

It is evident that many parameters have not been adequately addressed. These deficiencies are treated in detail in Part II of this report.

PART II

Data used in marine climatological studies are derived from many sources. The most frequently used data ~~bases~~ are listed below:

Sources

- Transient ships
- Weatherships
- Drill rigs
- Buoys
- Land Stations
- Hindcasts

Other data sets sometimes used for specific studies include satellite, radar and operational model data.

The data obtained from these data bases vary widely in quality, quantity and applicability for climatological analysis.

The data quality is affected by the instrumentation and the training and motivation of the observer. All shipboard data are prone to problems arising from instrument siting and the effect of the superstructure on the measurement. This is a particularly serious problem on drill rigs. On many transient ships instrumentation is limited, leading to estimated values for many fields. Instrumentation at land stations is generally well-sited, but the data are often not representative of the marine environment.

Training of observers is highly variable, ranging from several months for AES and weathership observers, to one or two weeks for drill rig personnel, to nil for many observers on transient ships. Motivation is also an important factor; weather observing is not the primary function for some observers.

Spatial coverage of marine areas is poor for land stations, buoys and weatherships, and is variable for drill rigs and transient ships. Drill rigs operate only in a few specific locations, while transient ships tend to follow well-defined shipping lanes, leaving many data-sparse areas.

Temporal coverage is very good for land stations and weatherships. Drill rigs and buoys provide good time series, although of limited extent. Transient ship observations extend from the 1800's, but do not provide useful time series.

Only data from land stations and weatherships are appropriate for many important climatological analyses, such as persistence and extreme value analysis, although drill rig and buoy data may be used in limited persistence studies.

To overcome this deficiency, hindcast data have been produced, particularly for wind. Hindcast data are synthesized from historical records such as surface and upper air weather maps, using theoretical models of the atmosphere and ocean. As such, they must be verified against quality surface measurements. Hindcast data are ideally suited to most climatological analyses from the point of view of spatial and temporal coverage provided that their accuracy has been confirmed by comparison with ~~requirements.~~ measurements.

Satellites have been used increasingly in recent years to produce data for a wide variety of parameters. As satellites do not measure directly the values of the required parameters, their data must be verified against surface measurements. Present satellite data bases are inappropriate for any climatological analysis, due to their short term and the sporadic nature of their coverage.

The primary factor inhibiting our understanding of the marine environment is a general lack of baseline data for all parameters, particularly in winter.

As a result, many important analyses can not be performed, and some that are done are of questionable quality.

The present data base of wind information is insufficient to adequately define the temporal and spatial variability of the wind field, the effects of structures on the wind field, or the extreme values to be expected.

Similarly, few measurements of icing exist over the ocean, particularly with respect to its vertical distribution. Thus it is difficult to verify existing methods for producing icing statistics, or to develop new techniques. For atmospheric icing, most of the present techniques were developed over land, so their applicability to the marine environment is unknown.

Visibility and cloud ceiling measurement can be quite difficult at sea, especially at night. Therefore, the statistics of these data are somewhat questionable. Shipboard automatic stations would provide consistent information on these parameters.

The present density of sea surface temperature observations is inadequate to describe the complex nature of the sea surface temperature patterns on the east coast, particularly near the Gulf Stream. Some work has been done using infra-red sensors from satellite, but these analyses are frequently curtailed by cloud. Microwave sensors, capable of penetrating cloud are not yet operational.

Weather conditions at supporting land stations may critically affect emergency response capability, yet very little work has been done regarding the frequency of adverse weather, particularly flying conditions, at these locations.

Hazardous conditions may result from combinations of factors, such as high winds, low visibilities and heavy icing, that would not occur with their independent occurrence. However, evaluation of these combinations has been overlooked to date.

Little work has been done on the measurement and/or analysis of air temperature, rainfall rates at sea, low-level atmospheric turbulence or lightning.

Recommendations to improve the knowledge and understanding of marine climatology on the east coast of Canada are listed below, by category:

General

Detailed reviews of the state-of-the-art are required for wind and icing, including a comprehensive literature search and recommendations for a coordinated action plan.

More high-quality baseline data are required over the ocean for all fields.

Data Acquisition

Drifting buoys, measuring a few parameters such as atmospheric pressure, air and sea temperature, should be regularly deployed along the east coast.

Moored buoys, similar to those now operated by the United States, should be deployed on the Scotian shelf and Grand Banks.

Shipboard automatic stations should be implemented wherever possible on ships and rigs.

A program should be initiated on and around several drill rigs to measure the variability of the wind in space and time, and the effect of the rig on airflow. Experimental turbulence measurements should be done simultaneously.

A program should be initiated to measure ice accretion on supply ships, drill rigs and helicopters, including the vertical distribution of icing. This data should then be compared against theoretical values.

Satellite systems capable of measuring atmospheric and oceanographic parameters should be supported. Of particular importance are wind measuring scatterometer systems, and microwave sensors for sea surface temperature.

Investigation into the utility of high frequency radar and bottom-mounted acoustic sounders for wind measurement should be initiated or continued for Canadian waters.

Existing hindcast data sets should be evaluated against quality measured surface data. If no suitable hindcast sets can be identified, a new, hindcast, specific to Canadian coastal waters, should be produced.

Climate Analysis

Published climatologies, contingency plans and impact statements should include, in addition to the frequency analyses usually produced:

Persistence, extreme values and gust factors of winds.

Persistence analysis of low ceilings and visibilities.

Frequency and persistence of icing conditions.

Frequency of thunderstorms and heavy rains.

Minimum and maximum air temperatures, persistence of high and low values, and windchill frequencies and extremes.

Statistical summaries of cyclonic storm distribution, frequencies, persistence and intensity.

Joint frequency distributions of hazardous combinations of conditions, such as high winds and low visibility.

Frequencies and persistence of adverse weather conditions, particularly flying weather, for all supporting land stations, both independent of, and combined with, adverse weather conditions at drill sites.

Weather Forecasting Services for the Canadian Offshore

DRAFT

Prepared for

The Royal Commission
on the
Ocean Ranger Marine Disaster

By

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February, 1984

SUMMARY

It is self-evident that many aspects of offshore exploratory drilling for oil and gas are affected by weather, and that from time-to-time human safety is threatened by adverse weather at sea. It is logical, then, to inquire into how the forecasting of severe weather is carried out in Canada, as it relates to offshore exploration, and how and what information is provided to operators so that they may take actions appropriate to ensuring safety. This report describes weather forecasting services in Canada and traces the flow of information through the Atmospheric Environment Service to the private forecast firms with whom the operators deal on a daily basis. It also discusses some important aspects of data acquisition, and describes a number of severe weather conditions which present difficulty to forecast services. Forecast preparation and presentation are reviewed, together with verification procedures used by various agencies. Conclusions are presented on forecast content, presentation and verification. The question of forecast adequacy is discussed in terms of the information level of forecast presentations and in terms of the relevance of information that is, or could be, presented to the offshore user.

The present study concentrated on forecasting services and the data disseminated by them to the end-user, the offshore operator. The terms of reference did not include a study of how forecast data are used by operators, at the shore base or on the drilling unit, to arrive at decisions affecting rig activities at sea. The affect of this on an assessment of adequacy of forecast data for ensuring human safety is discussed, and recommendations are given for examining this side of the question.

Traditionally the Atmospheric Environment Service (AES) has been responsible for weather forecasting throughout Canada. Marine and aviation forecasts fell under their jurisdiction in addition to forecasts for general public use. Under regulation of

offshore drilling, first by the Department of Energy, Mines and Resources, and later by the Canada Oil and Gas Lands Administration (COGLA), operators were required to contract location- and route-specific weather forecast services. In the Eastern Canadian offshore these services were provided by private corporations catering specifically to this need. Again by regulation, these firms had to have personnel trained by the AES or to AES standards. Because of this, and the central, dominate role played by the AES, a strongly hierarchial, and in many respects redundant forecast service has evolved.

We have found that all of the groups involved in forecasting are tightly linked, especially at the level of the AES regional weather offices and the private forecast firms, because prognoses are based on the same cascade of information from within the organization, and because weather forecasting is approached using the same meteorological principles and equipment. One apparent consequence of this parallelism in public and private forecasting groups is a profound similarity in the preparation and presentation of forecast material. As a result there are no significantly different forms of data presentation available to offshore operators despite the apparently different sources to which they could turn in severe weather situations.

We have also found the level of information presented in forecasts to be extremely low judged against what could be done if full advantage were taken of electronic data processing, transmission and display facilities now available. Several causes were identified:

i) close adherence to traditional procedures and formats developed largely for lay-public consumption,

ii) use of simple, meteorological parameters to represent complex atmospheric and sea state conditions at a rig location, giving little or no indication of spatial variations to be expected, and

iii) the generally low accuracy of individual parameter values in terms of what one normally associates with engineering criteria for rig operations.

One is also led to question the relevance of some forecast information since it deals exclusively with atmospheric or wave height/period parameters. For decisions affecting drilling operations -- downhole activities, resupply, extreme rig behaviour for normal and abnormal circumstances -- that may have to be made by non-specialists in meteorology and oceanography, prognostic information on, for example, rig or supply boat motion response or crane derating values may be much more useful than traditional forecast parameters.

There is evidence to suggest that many dangerous situations which arise at sea are associated with what are termed mesoscale phenomena. These are weather features that form and move so rapidly, and which have such small dimensions, that they are not incorporated into synoptic scale forecasts. There are two contributing factors to this: first, mesoscale events generally escape observation and hence do not enter formally into the analysis and prognostic procedures, and second, the physics governing their formation and interaction with larger scale systems is not well enough undersoood to make them forecastable with any real confidence. It appears that this is one aspect of forecasting that warrants further research, seeking first to establish the nature of the problems in more detail, and then examining ways of detecting and forecasting small scale events. It seems likely that improvements in forecasting mesoscale phenomena would demand innovative approaches to presentation techniques.

In terms of verification procedures we have found that there are no standards which apply equally to all agencies providing services. Thus it is very difficult to make any assessment of relative performance. In a preliminary study of NORDCO Ltd. and

AES forecasts for the Grand Banks, we have found that neither organization consistently outperforms the other, although NORDCO, like other private forecasters, attempts to provide more detail in their presentation. There does not appear to be any basis on which to claim that provision of forecast services by private firms to the offshore is inadequate, relative to standards that could be established for the AES itself.

However, to judge the adequacy of forecast information to offshore operators, in an absolute sense, requires an assessment of how well the data meet their needs for making decisions that affect the security of their rigs and the safety of personnel at sea. To do this an examination of the entire relationship between regulatory expectations for offshore safety, the utilization of weather forecast data by operators to satisfy these expectations, in their central coordinating offices and on the rigs, and the ability of forecast agencies to provide the required data is necessary. In view of our conclusions on the information content and relevance of forecast data, on the one hand, and the apparent success of civilian aviation weather forecasting, on the other, we recommend the above type of study be undertaken.

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DRAFT

An Assessment of the State of Knowledge of East Coast Offshore Wave Climatology

J.R. Wilson

Marine Environmental Data Service

W.F. Baird

W.F. Baird and Associates

June 1984

ABSTRACT

This report assesses the availability and adequacy of ~~the~~ on wind generated waves data required by the oil and gas industry, including design organizations, owners or operators, classification societies, regulatory agencies and research organizations for the development, design, construction and operation of structures to be used in the activities of exploratory and delineation drilling in waters off the East Coast of Canada.

It is found that the minimum requirements of the design, owner, classification and regulatory organizations for wave data are well defined in the available literature and that if these data are available safe and efficient design of structures and associated operations are expected.

It is concluded that the required data are not available throughout the study area. Reliable estimates of the required extreme wave conditions may only be available for the Hibernia area and even with these data there are some concerns. Throughout the remainder of the study area data suitable for the estimation of extreme events do not exist. Wave climate statistics suitable for the analysis of operations may exist for some locations in the southerly part of the study area, although limitations of these data are also identified. An important requirement identified, is the need for simultaneous observations or predictions of waves, currents and winds. It is not clear that this requirement has been adequately addressed over the study area. The availability of current and wind data is the subject of other reports and has not been examined here.

The future sources of wave data and information on extremes and wave climate are examined and conclusions are drawn. It is concluded that in the near future these data will continue to be developed using traditional techniques. However, improved advanced instrumentation and improved hindcast models better suited to the requirements of the various parts of the study area must be developed and implemented.

Satellite and other remotely sensed data will begin to become available within the next decade in useful quantities and will immediately begin to be useful for operations through improved forecasting. However these additional data will not improve the knowledge of wave climate and extremes for a number of years until a significantly increased database has been accumulated.

The present practice of developing knowledge of wave climate and extreme conditions in the study area is examined. It is noted that this knowledge is now acquired by an accumulation of information from many independent studies which are generally of insufficient scope and not fully co-ordinated with other programs. These studies tend to raise more questions than they answer and often disagree with each other. It is concluded that there is a need to develop joint programs between all interested parties to organize, priorize and carry out the studies to acquire the necessary wave information in the study area.

DRAFT

Oceanographic Information of the
Eastern Canadian Offshore

Adequacy for Exploratory Drilling

A Report To
The Royal Commission
on the
Ocean Ranger Marine Disaster

By

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April 1984

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SUMMARY

Exploratory drilling units operating off Canada's East Coast must take certain oceanographic conditions into account, both for design and selection of the appropriate vessel or jackup rig, and for safe operations at sea. The most important of these are extreme currents and extremes of temperature. This report contains a review of oceanographic information for the offshore area extending from the Southern Scotian Shelf to Baffin Bay. Relevant oceanographic parameters are first defined and measurement techniques widely used now to quantify them are outlined. Analysis methods and predictive models are then discussed, followed by a description of available data and their distribution. Finally conclusions on the present state-of-knowledge and adequacy of data for drilling needs are presented.

In describing ocean currents and water masses, basic physical parameters (current speed and direction at a point, temperature, salinity, and density) are, and have always been used in modern oceanography. These paremeters are entirely appropriate because they are fundamental to a dynamical understanding of currents, and they can be measured with acceptable accuracy. Measurement techniques were found to be generally adequate. It was noted that Aanderaa current meters, which do not have vector averaging capability, are still the mainstay of current measuring programs; improvements in data quality would accompany their replacement with vector averaging instruments.

We also found no evidence to suggest that analytical techniques are inadequate for data being collected in Canadian waters. Problems that do exist have more to do with what data were collected, and where, than with analysis methods used on them.

Predictive models for extreme currents, other than the tidal components, rely on long-term time series measurements. It has been shown, for example, that to achieve a 10% error in the variance of mean currents about 30 years of data are required. These data are not available in the offshore area, with the result that estimates of current extremes produced by factors other than tide, and, perhaps, wind, have very low confidence.

Methods for hindcasting wind-driven currents, using either empirical or deterministic models are available, but to date have not been applied for the region. Over the Northern Grand Banks, the Scotian Shelf around Sable Island and Lancaster Sound there are sufficient data to attempt this form of modelling with an opportunity to verify the results.

In many locations there are now good data records for tidal currents analysis and prediction, and reliable estimates of extreme tidal currents can be made. The major difficulty lies in extending current data from one site, where measurements have been made, to another without data. Numerical tidal modelling could assist in this, but to date there are no model data north of the Gulf of Maine and there is a severe lack of open ocean tidal data with which to operate these models elsewhere.

Measured current data were found to have originated from three main sources: government scientific research, industry baseline studies of a regional nature, and industry deployments in conjunction with well drilling. Considered together in terms of their spatial and temporal distributions, it appears that no master plan for making measurements has evolved that is oceanographically sensible. Data available

now form a haphazard set of short-term records largely clustered around areas of active drilling or discovery. Systematic long-term measurements at locations strategic for delineating major currents or providing input data to predictive models have not been made. Consequently available data are largely inadequate for deriving current extremes with the confidence one normally associates with wind and wave criteria. In certain areas, Hibernia, Venture and Lancaster Sound, there are data with which to make estimates, albeit with low statistical confidence. Removed from these sites, however, it is extremely difficult to specify design currents having an accuracy equivalent to wind and wave criteria.

Canadian practice for archiving data has been fragmented such that water property, water level, wind, wave, and current meter data are all stored in separate databases often at different locations, and following different formatting systems. As a result it is a difficult and frustrating process to assemble the concurrent records needed for a proper dynamical evaluation of ocean currents. This archiving procedure mitigates against use of those few data that are available for estimating current extremes other than by the most basic statistical methods. Moreover, designers are increasingly turning their attention toward joint occurrences of extremes in wind, waves and currents. The organization of historical data makes this type of analysis difficult also.

Thus, from an oceanographic perspective we have found many shortcomings in where data have been collected and how they are stored for later use, and these have a direct impact in how well design currents can be evaluated. We also note, however, the existing data, scientific interpretation of

them and industry studies have not revealed conditions that are beyond the drilling technology in use today, nor that appear to be limiting for design over most of the East Coast. A decade of offshore experience has also failed to turn up serious problems that could be attributed to ocean currents or extremes of temperature. The effects of waves and ice are much more serious.

As a result it cannot be concluded that present oceanographic knowledge is inadequate for offshore drilling needs as they impact on safety. With the exception of Hudson Strait and Flemish Pass necessary criteria on currents, water levels, and water properties can be estimated and adequately allowed for in design. In these two areas, however, and in deeper water along the continental shelf break, more data will likely be needed to plan safe drilling programs.

In view of our findings on oceanographic practices and anticipating an expanding offshore drilling industry, it would seem logical to reorient data collection along more rational lines than are presently followed. Essential aspects would include:

1) establishing predictive techniques and data requirements for current extremes;

2) organizing long-term strategic monitoring stations for all necessary parameters;

3) standardizing instrumental and analytical techniques; and

4) putting all data into one archive suitable for a dynamical analysis of winds and currents, in combination with wind waves.

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April, 1984

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PROJECT 2849

REPORT

TO

THE ROYAL COMMISSION ON THE OCEAN RANGER MARINE DISASTER

ON

THE ADEQUACY OF AVAILABLE SEABED INFORMATION AS INPUT TO DESIGN CRITERIA AND OPERATING CONSTRAINTS FOR EASTERN CANADA OFFSHORE EXPLORATORY DRILLING

Jacques, Whitford and Associates Limited
January 31, 1984

SUMMARY

This report presents the results of a study to assess the adequacy of available seabed information as input to design criteria and operating constraints for eastern Canada offshore exploratory drilling. The primary emphasis of the study is evaluation of the adequacy of the information in terms of the influence of seabed conditions on safety.

Both the type and distribution of seabed sediments and the occurrence of significant geologic features have to be considered in the assessment of seabed conditions. Available data on the types and distribution of eastern Canada offshore sediments is based primarily on geophysical surveys and geological interpretation; a condensation of these data is presented as a mapping of seabed sediments. Potentially significant geologic features and conditions have been identified in the eastern Canada offshore; these are discussed in the report but available data are not sufficient to permit their mapping.

Exploration drilling equipment which interacts with the seabed includes jack-up drilling rigs, anchors, and well conductors. The most critical interaction is that of jack-up units which depend completely upon the seabed for their support and which are susceptible to a variety of foundation problems. Analytical procedures are available for predicting the behavior of jack-up unit foundations and for designing well conductors; the design and performance of anchors are based on empirical methods and proof testing.

For input to design criteria and operating constraints, detailed information on the geotechnical properties of the seabed sediments is required. Available data determined from geophysical surveys does not provide the required geotechnical information and is not sufficient to permit evaluation of the effects of seabed conditions on the safety of offshore drilling operations. It is therefore concluded that the available seabed information is not adquate as input to design criteria and operating constraints for offshore exploratory drilling.

CONCLUSIONS

The safety of exploratory drilling operations in the eastern Canada offshore is significantly dependent upon seabed conditions. In terms of safety, jack-up rigs represent a greater potential risk than other elements which interact with the seabed, such as anchors and well conductors.

In order to minimize the safety risks associated with exploratory drilling operations, detailed knowledge of the seabed is required. This knowledge includes the identification and engineering assessment of geological features which may occur at the site as well as identification and evaluation of the geotechnical parameters (soil strength, density, etc.) pertinent to the site and application in question.

The present knowledge of the seabed conditions on the eastern Canada offshore is not sufficient to effectively predict the performance of structural elements which interact with the seabed. The data available consist primarily of geophysical records which, with the coverage to date, have permitted only the development of regional mapping. Such mapping does not provide site specific information regarding the presence or absence of potentially hazardous seabed features. As it is not feasible to increase the coverage to a level where potential hazards at all future sites are identified, geophysical surveys are necessary on a site specific basis. Site specific geophysical surveys will be most meaningful if tied into the current regional geologic framework.

Information on the geotechnical parameters of the seabed sediments which is required for performance prediction and analysis of seabed-structure interaction is almost entirely lacking and is therefore totally inadequate. Even with a comprehensive geophysical data base, the geotechnical parameters would remain unquantified. As obtaining geotechnical information on a regional basis in the detail required for analyses at a particular site is even less practical than obtaining comparable geophysical information, site specific

geotechnical investigations are necessary. These investigations will be most useful if conducted in conjunction with site specific geophysical surveys and related to the current regional geologic framework.

Present geophysical and geotechnical equipment and techniques are sufficiently advanced to obtain the type and quality of data required for evaluation of seabed-structure interaction. Similarly, proven methods exist to predict the performance of structures on the seabed after adequate data has been obtained. Conventionally, the factors of safety used for offshore structures are smaller than used for structures on land. Increased factors of safety would be required to provide margins of safety which are comparable to those provided on land.

Existing statutory regulations applicable to the overall eastern Canada offshore do not specifically require geotechnical investigations at proposed drill sites. They thus do not ensure that the information required to quantify the risk related to seabed-structure interaction is obtained. Requiring site specific geotechnical investigations would provide the data necessary to minimize the risks involved with offshore exploration activities.

AN EVALUATION OF THE MANAGEMENT OF THE REGULATORY PROCESS IN EASTERN CANADA OFFSHORE DRILLING

Submitted

to

ROYAL COMMISSION ON THE

"OCEAN RANGER" MARINE DISASTER

NATIONAL PETROLEUM AND MARINE CONSULTANTS LIMITED

June, 1984

EXECUTIVE SUMMARY

With the rapid development of exploration activity off Canada's East Coast, the safety of personnel involved in this industry and government's responsibility for regulation of that safety have become issues of interest and concern. A complex regulatory system has arisen due to a host of historical, geographical, technical, administrative and political factors. The need to sort out and examine this regulatory process has given rise to this study.

The objectives of the study are to describe the organization and management structures of the federal and provincial agencies involved in the regulation of safety in Eastern Canada offshore drilling and to evaluate their effectiveness.

A detailed summary of the organization of each of the primary agencies involved was produced. Federally, these are the Canada Oil and Gas Lands Administration, the Canada Coast Guard and the National Search and Rescue Program. Provincially, the Newfoundland and Labrador Petroleum Directorate and the Nova Scotia Department of Mines and Energy are the lead agencies. In addition to these, a host of secondary federal and provincial agencies are involved. The organization of these and their relation to the primary agencies was described. Next, a detailed description and discussion of the administration and functioning of all the agencies involved was produced. Included in this was an examination of the major regulatory activities as they now stand and a list of significant recent or proposed changes to the structures.

The study team had meetings with and collected information from the agencies and from relevant petroleum companies and contractors. This information was combined with the study team's own knowledge of these agencies to

produce an evaluation of the regulatory regimes described. Significant concerns related to potential deficiencies in the systems were identified and analysed.

The areas of concern were categorized as general organization and policy, development of regulations, applications and permits, inspections, monitoring and enforcement, specific areas requiring special regulatory attention, and liaison between primary agencies and other groups.

Those concerns which the study team concluded were valid led to the recommendations in this report. The most important of these are cited here.

- In the federal system, the responsibility of the lead agency (i.e. COGLA) for the performance of other agencies should be clarified.
- Regulatory agencies should establish an internal set of procedures/guidelines that set out the methodology for designing and promulgating regulations, the basis on which regulations are reviewed and amended, and the methodology for handling industry requests for changes.
- Provision should be made for a formal appeal system where industry has the opportunity to put forward to regulation agencies alternatives to particular requirements.
- Industry should be invited, consistently, to provide input at the early stage of development of regulations.
- A definition that sets out the legal authority of directives, guidelines and standards should be generated and published.
- Regulatory agencies should have recognized procedures in place for testing and approval of safety equipment.

- Regulatory agencies in the federal system should establish a formal mechanism for input of workers' safety committees into safety regulatory matters.

- COGLA and Transport Canada should formulate a workable set of standards for helicopter landing facilities taking due consideration of developing international standards.

- There should be improved co-ordination of initial inspection and survey of drilling units to minimize any overlaps and gaps.

AN EVALUATION OF INDUSTRY SAFETY MANAGEMENT IN EASTERN CANADA OFFSHORE DRILLING OPERATIONS

Submitted

to

ROYAL COMMISSION ON THE "OCEAN RANGER" MARINE DISASTER

MANADRILL DRILLING MANAGEMENT INC.

JUNE 1984

EXECUTIVE SUMMARY

The Royal Commission on the Ocean Ranger Marine Disaster has called for a number of studies to"inquire into, report upon, and make recommendations with respect to" a number of safety issues related to the marine and drilling practices and procedures utilized by Industry in offshore drilling operations.

The objective of this study is to assess critcally the method used and the degree to which Operators and Drilling Contractors regulate the safety of Eastern Canadian offshore drilling operations.

A detailed questionaire was developed and sent to all Operators and Contractors with activities in Eastern Canadian waters during 1982 and 1983. Following receipt of a number of formal responses to the request, a series of interviews were conducted with those companies to amplify the data base. The study team also held meetings with the prime Regulatory Agencies.

The study emphasis was directed toward an objective evaluation of the offshore drilling Industry's ability to conduct operations in a safe and efficient manner within the framework of the regulatory regime imposed by the Government Agencies. The areas of specific interest included well control, lifesaving equipment and procedures, marine emergency training and marine procedures.

The organizational structures of the Operators and Drilling Contractors were reviewed along with the contact relationships between Industry and the Government Agencies.

The eastern Canadian operating environment is complex, everchanging, physically hostile and politically sensitive. In the time covered by the study period a large number of changes have taken place in this environment. Governmental agencies have undergone major organizational restructuring and many new functional departments have taken a sudden interest in the control of the offshore industry. The industry itself has made a transformation from the predominance of the multi-national, major Operators and large established multi-rig international Contractors to the new Canadian independent Operators utilizing a group of new Drilling Contractors with a complete range of equipment types and a variety of operating styles.

The large variations in the physical environment that characterize east coast offshore operations dictate the use of a wide range of equipment and operating procedures, and tend to increase the requirements for extensive and specifically tailored safety contingency plans. The Industry operates in one of the world's most complex and hostile environments and as a result must place a high degree of emphasis on safety.

These internal and external pressures have a tendency to complicate the Operator's environment and his ability to control the overall safety of the operation. The Operator must ensure that all these variables are taken into consideration in dealings with the Drilling Contractor and the Regulatory Agencies during the planning phase of an offshore program to ensure that safety is not compromised.

This complexity is manifested when considering the complicated regulatory regime that has been developed to maintain the standards and rules governing offshore operations.

The study team found that there has been a significant degree of improvement in the safety of offshore operations and in the administration of the overall regulatory control regime during 1982 and 1983. Industry and Government are working together in several key areas where there are common concerns and mutual understanding of weaknesses in the system. Significant steps have been taken by Industry and Government in implementing new ideas, new and improved equipment and systems and in the development of an Industry oriented, training and development program philosophy. Industry and Government have reached a reasonable level of understanding of each other's roles and objectives.

It is the opinion of the study team that the most significant development during the period has been the marked improvement in safety awareness on the part of Industry employees, supervisory staff and senior management.

The Regulatory Agencies have matured significantly during the time and the local administration of Government policies in the operating areas has been a positive step in improving communication between Industry and Government. There has also been a definite relaxation of some of the politically oriented, local employment, goods and services issues that had begun to undermine the working relationships between Government and Industry early in the study period.

The team has however, identified a number of areas of concern in the overall management of the safety regime. These are generally related to marine oriented or non drilling issues and in most cases are related to activities that are under the control of the Drilling Contractors. The majority of these concerns can be traced to what appears to the study team to be a weakness in the overall regulatory control system. The Drilling Contractor, who owns and operates the offshore equipment and who employs the majority of offshore workers, is effectively isolated from the Regulatory Regime that controls these basic components of the Industry.

The concerns in most cases relate to a lack of understanding of the Contractor's business on the part of the Operators and the prime Regulatory Agencies. The Operators and the Regulatory Agencies are forced by the structure of the Control Regime to make decisions of a regulatory nature on detailed issues affecting the Drilling Contractor's equipment, procedures and personnel. These decisions are sometimes carried out without formal effective input from the Contractor and in many cases without the input of those secondary Regulatory Agencies who may have a knowledge and understanding of the specific issues.

Those detailed concerns, which the study team feels are critical to the success of Industry in its management of the safety regime, are addressed in the study. They could be reduced, if not eliminated, by action on the following key recommendations.

1. The roles and responsibilities of the primary and secondary Regulatory Agencies must be clearly defined and any overlapping responsibilities eliminated.

2. Industry must develop strong, dynamic and operationally oriented Industry Associations to deal with Government on issues common to all members.

3. Marine lifesaving equipment must be upgraded through the advancement of lifesaving technology to the level of the technology of the MODU's themselves.

4. There should be a direct, working level connection established between the aviation control agencies and the offshore Control Regime to ensure that the safety of offshore helicopter operations is being effectively monitored.

5. The operation of supply vessels alongside MODU"s should be evaluated to determine reasons for a number of incidents involving collision of the supply vessels with the MODU's.

6. The Regulatory Regime must develop a system to ensure that all MODU's are administered in a consistent manner regardless of the flag of registry.

7. The Operators and Government Agencies should put publicity and politically oriented pressures aside when dealing with the development and administration of safety oriented issues. The controversy around random versus scheduled emergency drills must be evaluated in isolation from these pressures. The Drilling Contractors should be given the responsibility to develop an acceptable system that meets the true safety requirements.

The guidelines covering planned evacuation from MODU's in the case of pending bad weather should also be evaluated by the Drilling Contractors in conjunction with the Operators and Government to ensure that all aspects of this approach are considered again in the light of true safety requirements and isolation from external political pressures.

8. The Operators must re-evaluate the utilization of supply vessels in the role of standby support to ensure the standby role is not compromised during the transfer of a vessel from one operating mode to the other.

9. Drilling Contractors should review practices covering safety meetings and drills to ensure there is an effective employee feedback process through which offshore workers can express concerns and receive satisfactory answers to their questions on matters of safety.

10. Operators and Government Agencies must develop a better understanding of the Drilling Contractor's activities and safety control philosophies in order to more effectively develop regulatory controls governing these issues. They should strive for the development of an effective process that will ensure input to the system from the Contractors and the secondary Regulatory Agencies specializing in contractor related issues.

11. Industry and Government must continue the development of an overall training and development program based on the Drilling Contractor's training requirements, that is consistent with accredited international programs and allows the Contractors to use the vast training resources available within their world wide organizations.

12. Although the study indicated a significant degree of comfort with the Well Control Regulations and the

Industry's ability to manage this area the study team feels that it is necessary to raise a warning flag. The overall Well Control process and the success of Industry in this critical management control area of offshore operations are vested in a group of individuals whose ability to prevent serious well control events depends on their total dedication to the wellbore pressure detection process. The best equipment and procedures available, coupled with the best training programs will be to no avail if these key individuals are not committed to maintaining constant vigilance and total awareness.

13. Operators and Government Agencies must develop a strong understanding of the Drilling Contractor's organizational command hierarchy and the differences between the marine oriented and drilling oriented approaches. They should then allow the Contractors to demonstrate their individual capabilities in managing their activities in a safe and efficient fashion irrespective of a particular command philosophy.

Industry is in general agreement that there should be one individual on board a vessel who is in ultimate control at any given time. That individual must obviously be competent in his management and leadership capabilities and he must have a strong knowledge and understanding of both the drilling and marine aspects of the operations with accredited certification in both areas.

Operators and Government Agencies with little knowledge of the management of Contractor's personnel and operating systems should not interfere with the basic safety control philosophies of the Contractors. These systems have been developed over many years of experience and have demonstrated a good safety record.

Industry and Government should set aside differences surrounding the two management styles and work together to develop a consistent approach to the command hierarchy. The objective being the establishment of rules and regulations that would ensure strong basic safety requirements and yet allow the flexibility for Contractors with differing management philosophies to operate according to their best judgement.

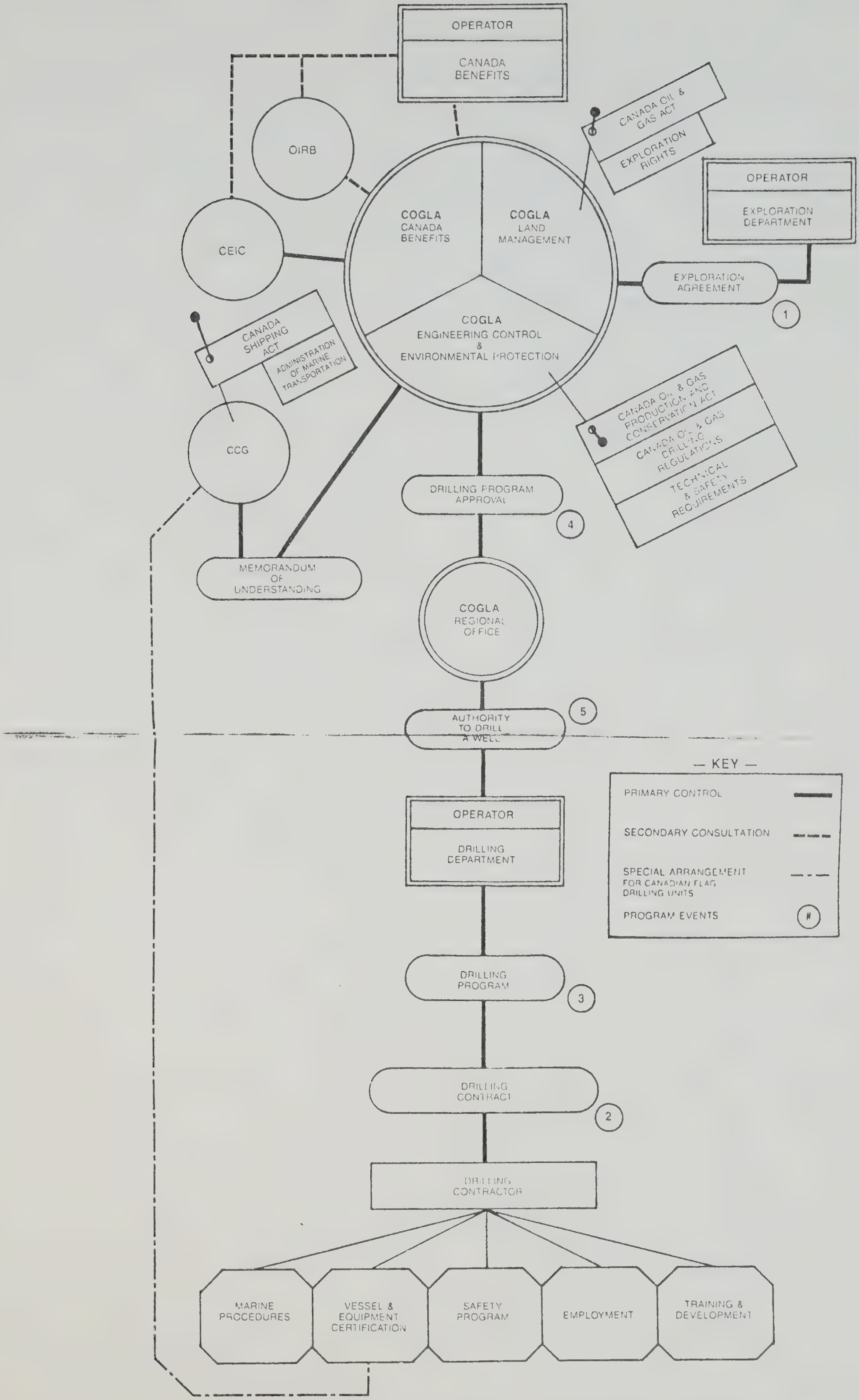


FIGURE: 6-1 CONTROL REGIME FOR EXPLORATORY DRILLING ON CANADA LANDS

DRAFT

TO APPRAISE CRITICALLY THE DESIGN, OPERATION AND PERFORMANCE MONITORING OF SYSTEMS CRITICAL TO THE SAFE OPERATIONS OF MODUS

FINAL REPORT

Submitted to:

Royal Commission on the
Ocean Ranger Marine Disaster
St.John's, NFLD

by

Det norske Veritas (Canada) Ltd.
St.John's, NFLD, Calgary, Alberta

June 1984

EXECUTIVE SUMMARY

The Final Report on the study "to Appraise Critically the Design, Operation and Performance Monitoring of Systems Critical to the Safe Operations of MODUs" is organized in four parts. The scope of each part is outlined in the Introduction following this Executive Summary.

The Study Area is the Eastern Canadian Continental Shelf extending from US -Canada border to approximately 75 degrees N. The MODUs covered in the report and presently used in the Study Area are semisubmersibles, jack-ups and drillships. Drilling offshore Eastern Canada started about 15 years ago and two offshore fields have been identified (Hibernia and Venture), 17 gas strikes have been made and six major oil finds have been declared. It is assessed that with the 1983 drilling agreements concluded deployment of MODUs will peak to about 25 in 1984-85.

The design of MODUs has progressed through several stages over the last decade. Units have increased in size to accommodate higher loads, allowing them to work further from coastal bases and be less dependent on supply vessels. In the 1970's the load capacity was typically in the range of 1,500 to 2,000 tonnes, and increased to a range of 3,000 to 4,000 tonnes in the 1980's. It is questionable whether this trend will continue, as a large number of units are operated with far less than the maximum capacity.

Fourth generation semisubmersibles, currently being developed, include special design features for operation in harsh and cold environments. Referred to as "winterized semisubmersibles", these units can incorporate partly built-in working areas and derricks. Closing in these areas greatly improves the working environment, but also places strict requirements on the safety systems in hazardous areas.

Jack-ups have not as yet been ordered for deeper and harsher environments, however, they are competing with semisubmersibles for intermediate waterdepths up to 100 meters. As the rigs increase in size, the use of high tensile steel is required, and fatigue becomes a more important criterion in the design.

Safety relating to MODUs is probably best achieved by eastablishing certain "defence lines" against a whole range of hazards. As the first line of defence one should consider proper design and fabrication etc. The possibilities for efficient inspection and control should also be emphasized during the design stage. The second line of defence is linked to in-service inspection, etc. Tailor-made inspection programs for individual types of MODUs with due consideration of design concept, inspectability, fabrication history, instrumented surveillance, etc. are necessary in this context. For example, improved inspectability may be obtained by using closed members instead of free-flooded members ("leak before failure"). This second line of defence should also comprise operational limitations on the unit.

However, in order to avoid jeopardizing the safety of a MODU due to failure in the first two lines of defence, and more importantly, to be able to withstand possible accidental loadings (collisions, falling objects, etc.) a third line of defence should be established. This line of defence should give provisions for sufficient reserves to maintain structural integrity and hydrostatic stability for all probable accidental scenarios.

Situations may, however, still arise where even less probable accidental loadings occur, e.g. due to severe damage caused by collision, explosion, etc. Hence, a fourth line of defence may be mobilized to provide for safe protection and evacuation of the personnel onboard. In other words, consideration should be given to provide the MODU with residual strength and floatability sufficient to prevent sinking or capsizing as a consequence of severe damage in a given weather state. Emergency escape routes and equipment should be designed for such a damage condition.

The statistical basis for collecting historical data on offshore (MODU) accidents is relatively weak as the total operating period for MODUs is less than 5,000 rig-years. Large accidents such as "Ocean Ranger" and "Alexander L.Kielland" will therefore predominantly influence historical data on offshore accidents.

By combining an assessment and review of such statistical data with engineering judgement and interviews with rig captains and drilling section leaders on MODUs it is proposed that the following are the critical systems for safe operation of MODUs:

- Jack-ups: Structural, towing, well control and fire and gas detection systems.
- Drillships: Well control, structural, fire and gas detection, mooring and station keeping systems.
- Semisubmersibles: Well control, ballast, structural, fire and gas detection, mooring and station keeping systems.

Each of these systems are described in the report (Part II), which addresses also functional requirements and capabilities. Information on the actual performance of the critical systems are analysed for the identification of possible deficiencies and areas that need improvement and further development. Capabilities and limitations under emergency situations are also outlined, as well as the impact of human reliability factors on system capabilities.

In the study's development of design principles emphasize has been put on extreme and accidental environmental and operational conditions. The principles particularly address the systems that minimize the probability of progressive collapse arising from such factors as collision with ships or ice, dropped objects, fire and explosion and extreme weather conditions. Moreover design of primary, back up and emergency systems representing different "lines of defence" have also been considered. The provision of proper redundancy systems, adequate reserve of strength and stability after accident, floatability after severe damage, inspection, maintenance, monitoring, control and reliability of various systems are also highlighted in the study.

Design requirements should be established to ensure that the system is designed, built and operated with an acceptable safety margin against loss of life, pollution of environment and major economic losses.

There are two different approaches to design principles for the critical systems of MODUs: one for the structural system including structural stability and foundations (jack-ups); and the other related to system designs of mechanical installations etc. with more predominant reference to man-machine interactions. A detailed discussion on man-machine interactions and design principles relating to critical systems of MODUs is given considerable coverage in the Final Report. Emphasis has been put on the type of MODUs most frequently operating in the Study Area, with major focus on moored semisubmersible units. The Final Report contains descriptions of detail design principles relating to the critical systems identified in Part I and II of the Study.

The terms of reference for the study call for the selection of the most critical systems for safe operations of MODUs. In consultation with the Ocean Ranger Commission, and based on conclusions from Part I, and general safety issues covered in Part II and III, the following three most critical systems were selected for further study coverage:

- stability/ballast systems (of semisubmersibles)
- towing/transit systems (of jack-ups)
- well control systems

The basic safety features of these systems and the justification for their selection as the most critical systems are covered in detail in the Final Report.

As required by the scope of the study the design principles of the most critical systems for safe operation of MODUs and their appropriate references to existing Canadian regulations, it is important to remember that the contract relates to drilling units. The only two major and existing Canadian regulations/standards which will apply are therefore:

- Canada Oil and Gas Drilling Regulations, 1980 (Energy, Mines and Resources Canada)
- Interim Standards Respecting Mobile Offshore Drilling Units, 1984 (Transport Canada).

The Canada Oil and Gas Drilling Regulations cover the permit applications, procedures and operational aspects of the drilling mode and drilling equipment. As such it does not - and should not - contain details on the stability/ballast system of the MODU supporting the drilling operation.

The Interim Standards Respecting MODUs on the other hand covers stability and ballast system quite extensively. On intact and damage stability the Standards offer a wide coverage and impose requirements exceeding those of the IMCO MODU Code 1980. The design principles on stability that are discussed in this study are well covered in the Standards. The principle of system redundancy is partly covered in Parts III and IV of the Standards, but not given a specific reference but contained in the regulatory requirements. Failure analysis is not covered in the Standards, but it is questionable if such should constitute a regulatory requirement at present. The design principles associated with arrangement of the ballast system are also considered in the Standard, but referring to details in the Canadian Coast Guard Machinery Construction Regulations on "bilge and ballast pumping and piping systems". Design principles relating to components and equipment are only marginally addressed in the Standards. Such design issues are nevertheless seldom covered in detail in Standards or regulations; they are usually included in guidelines.

The Interim Standards Respecting MODUs have been based on the IMCO MODU-Code. Only intact stability requirements are comparable with the NMD-Regulations. The damage stability standards do not include "high-energy" damage nor "low-energy" damage involving two-compartment damage. On the other hand, the new Standards require, for column stabilized units, the ballast system to be capable of bringing the unit to a level condition from an inclination of 15 degrees in any direction, and where necessary stripping pumps shall be provided for this purpose. The Standards seem to meet reasonably well with the design principle that the ballast system should provide active counter-measures for unintended inclination that may endanger the safety and stability of the unit. Also the design priciples regarding control and indication of valves and pumps have been covered. The safety measures provided by the design principle that the unit should be designed with sufficient resistance or stability against overturning for relevant damaged conditions are not fully met in the Standards.

A two-compartment damage is considered realistic in the exposed areas of the columns and such design requirments should at least be included. In general passive safety measures (stability criteria) will be more reliable than the active measures (counter-ballasting) and should be fully utilized first. Equally important as the improvement of the ballast system, are the qualifications of the ballast system operators. Formal approvals of operators certification, training programs, emergency drills etc. are not covered in the Standards. It is of course debatable whether requirements to training should be included in regulations/standards - or more feasibly be covered as guidelines or instructions. It is, however recommended that the maritime authorities should address the training of ballast control system operators in formal documents.

The Interim Standards respecting MODUs consider jack-ups in transit, but not in any detail. The Standards do not apply to self-elevating or bottom based units when in the drilling mode. In the transit mode the units are regarded as seagoing vessels. The design principles linked to jack-up floatability/stability are considered in the Standard, but not with specific references or requirements. Towing arrangement principles are only marginally addressed but details on towlines are not covered.

The transit condition of jack-ups falls in a regulatory "grey zone", as it is not normally covered by drilling and/or structures regulations while in its operational mode at location on a continental shelf. It is not adequately covered in international or flag authority regulations in international waters. The Canada Oil and Gas Drilling Regulations do not address the basic design criteria or problems associated with towing/transit systems of jack-ups. It is not recommended that the drilling regulations should be ammended to cater for this transit mode. The interim standards do not address the drilling mode. In the floating mode including towing/transit, a general requirement calls for a post-voyage inspection to ensure that no damage has occured in transit and that the structure remains safe. When on tow the jack-up is regarded as a seagoing vessel for which the Canada Shipping Act applies. This is mentioned in the preamble of the Standards, however, it is recommended that proper reference to the Canada Shipping Act is made in the appropriate sections of the Standards. Provided

general considerations of the jack-ups as a non-propelled barge are made, it is recommended that further requirements to the towing operation are given, and at least a Towing Declaration should be required in connection with relocation of jack-ups in Canadian waters.

The well control systems are normally covered in national <u>drilling</u> regulations. It is also believed that fatalities caused or effected by improper well control cannot be attributed to regulatory requirements but mostly to human errors. The Canada Oil and Gas Drilling Regulations cover very adequately the design principles of well control systems discussed in Part III of this study. It is therefore not recommended to amend these regulations in regard to the design principles discussed.

The Interim Standards respecting MODUs only marginally address well control systems. The present coverage is deemed adequate provided reference is made to "Canada Oil and Gas Drilling Regulations" in the appropriate sections of the Standards. It may, however, be worthwhile considering the issue of "policy documents" covering instructions relating to organization, training and staffing of well control personnel.

REPORT ON

MOBILE OFFSHORE DRILLING UNIT

DESIGN EVOLUTION

Prepared for

Royal Commission on the *Ocean Ranger* Marine Disaster
Canada

Commission Royale sur le Désastre Marin de l'*Ocean Ranger*
Newfoundland/Terre-Neuve

JUNE 1984

EARL AND WRIGHT
CONSULTING ENGINEERS

2. SUMMARY

The following subsections summarize the major changes in MODU technology since the late 1940's. MODU design has evolved from the use of land based drilling equipment on shallow water barges to present day complex, large capacity world class drilling units capable of operating in severe weather and surviving the worst ocean storms. The present state of the art in MODU design is briefly described in Section 2.1.

Safety considerations have affected the development of all major MODU systems. The success of safety considerations in recognized MODU design has been proven over the years by a decrease in accident frequencies. Safety aspects are summarized in Section 2.1.

2.1 PRESENT STATE OF THE ART

Present generation mobile offshore drilling units are characterized by their ability to operate efficiently over extended periods in very extreme environmental conditions. All of the three principal types of MODU, drill-ship, jack-up and semisubmersible have extended their operating capabilities significantly from the first generation units. Typical operating limits for present day MODUs are as follows:

	Ship	Jack-up	Semisubmersible
Water Depth Moored	460 m	100 m	460 m
D.P.	1830 m	-	1830 m
Drilling Depth	7600 m	7600 m	7600 m
Deck Load	10,000 t	1500 t	4000 t
Max Wave Height	21 m	21 m	33.5 m
Max Wind Speed	100 kt	100 kt	100 kt

2.1.1 Semisubmersible Configuration

The semisubmersible MODU configuration has evolved as the most common configuration for operation in harsh environments due to its low motion response characteristics. Modern units are able to carry

deckloads in excess of 3600 t, and drill wells in excess of 7600 m deep. Moored operation in water depths in excess of 450 m and dynamically positioned drilling in water over 1800 m deep have been accomplished. The semisubmersible configuration has the greatest overall operability of the different MODU types.

2.1.2 Structural Arrangement

The structural configuration of the modern drillship is essentially unchanged from conventional ship structures with the exception of the midships moonpool necessary for drilling. With sizes ranging from about 60 m to almost 200m in length drill ships cover the same general shapes and sizes of small to medium size cargo vessels.

The most common structural arrangement for semisubmersibles is now the twin-hull semisubmersible, comprised of two pontoons supporting 4, 6, or 8 stability columns and deck structure. Columns and hulls are tied together by transverse and longitudinal tubular truss arrangements. The upper deck may be a single level platform or it may be a two-level barge deck or 'box' deck to gain topside space. The single deck configuration offers lower topsides weight and greater deck load capability, while the barge deck configuration can provide somewhat greater deck area and reserve buoyancy in the event of extreme list.

For shallower water and milder environments the three leg cantilever jack-up is the most common type of unit. These units have barge-type hull construction and either tubular or lattice truss legs.

2.1.3 Materials and Welding

The principal advancements in material selection for MODUs have been the introduction of higher-strength steels, low-temperature notch-toughened steels, and through-thickness steels used in high stress areas particularly in connections.

Higher strength steels were first recognized in shipbuilding practice in the 1960's, and these were eventually included in most classification society rules by the early 1970's. The latest classification rules now address selection criteria based on service application.

Welding techniques have advanced in the areas of pre and post-heat treatment, development of procedures for welding large thicknesses, and welding of high-strength low alloy steels. Principal achievements have been in reduction of pre-heat and post-heat requirements and in increasing weld deposition rates to achieve greater fabrication productivity.

2.1.4 Mooring System

For a long time, MODU mooring systems were limited to water depths of 180 m or less. In the 1970's winch capacities and chain and wire manufacturing techniques were improved to permit mooring systems to be designed for depths up to 450 m or more. Water depth extensions have increased the weight of mooring systems dramatically, leading to novel arrangements of mooring components, including conventional chain and windlass systems, combination chain and wire systems, and all-wire systems with drum winches. Present semisubmersible designs employing 8 line systems with 89 mm wire or 76 mm chain are equally common. The newest generation units are utilizing 12 lines with chain or wire of similar size.

In the past 5 years a number of semisubmersible units have incorporated dynamic positioning systems to eliminate water depth limitations. The reliability and controlability of modern thrusters gives dynamically stationed MODUs the capability to drill in water over 1200 m deep, and remain on station and connected to the wellhead in storms up to Force 9/10.

2.1.5 Ballast System

Present day semisubmersible MODUs have remotely controlled ballast systems capable of trimming or changing the draft of the unit quickly and accurately. These systems evolved from the early gravity fill independent tank systems to today's positive-fill systems with redundant controls and power sources.

Early jack-up units had only individual leg or corner pre-load tanks. Present generation jack-ups have bilge drain systems and pre-load tanks under centralized control. This allows better control of the critical loading and unloading of the legs.

2.1.6 Ballast Control Station

Early MODUs, particularly jack-ups, had no centralized control location for ballast pumps, and ballast control was dependent on coordination of operations among several local stations. Modern MODUs have taken advantage of sophisticated control technology now available to provide complete control of the ballasting function from a central location. Semisubmersible MODUs incorporate central ballast control panels containing tank level, valve status, draft status and pump control information in 'mimic' layout.

2.1.7 Propulsion System

Most early MODU designs were not self-propelled, with the exception of drillships, which utilized conventional ship propulsion systems. Tunnel thrusters were introduced in drill ships to provide some lateral assistance for conventional mooring systems, and gradually these were supplemented by retractable or azimuthing and retractable thrusters until fully dynamic positioned drillships were developed.

The early semisubmersibles had no propulsion system, but thrusters became practical for propulsion assistance on long ocean transit and for mooring assistance. Thruster units evolved from 600 to 1200 HP

fixed orientation propulsion assist units to present day 3000 to 4000 HP azimuthing units designed for dynamic postioning applications.

2.1.8 Mobility

First generation semisubmersible MODUs featured multiple column and hull arrangements which produced very poor performance while under tow. As the twin-hull semisubmersible evolved, transit condition performance gradually was improved by adopting optimum draft and hull proportions for towing. Bow and stern shapes were selected to minimize wave interaction with the stability columns. Some present semisubmersible MODUs have incorporated ship bows and sterns, including bulbous bows, to increase speed in the transit condition with less tug assistance.

Jack-up units have also seen improvements in hull shape, including radiused bilges and leg/spud can fairings to reduce towing resistance. When long moves are contemplated for these units, special purpose transport barges are often utilized to carry the jack-up by various dry tow methods. This operational development has reduced considerably the risks inherent in transporting jack-up units over long distances in rough seas.

2.1.9 Stability

In most early MODU designs, stability considerations were limited to provision of sufficient GM and waterplane area to resist the effects of 35 m/s to 50 m/s storm winds. Gradually other considerations were addressed, and accidental flooding criteria were adopted to enable MODUs to survive damage resulting from boat collisions. Classification societies included intact and damage stability requirements in their rules, beginning with the ABS rules for MODUs in 1968.

Present generation MODUs are designed to meet extensive stability requirements. MODUs are now designed to withstand a worldwide standard severe storm criterion, plus flooding due to waterline collision damage or other accidental flooding of the hull.

Drillships and jack-ups are designed to meet one-compartment damage flooding standards, following conventional ship design practices. Semisubmersibles are designed to meet multiple compartment flooding standards for waterline damage while in operation and any one-compartment flooding for other cases.

2.1.10 Payload

First-generation units were designed to carry 500-1000 t of deck load. Drilling locations eventually extended to remote areas where re-supply considerations dictated large deck load capability. Drill ships had no difficulty in providing deck load capacity in excess of 3600 t but even the largest early semisubmersibles could carry only 1400 t on the average. Present generation semisubmersibles average 2,700 t deck load, with some designs capable of carrying 3,600 t or more at operating draft. This increased capacity enables units to be less dependent upon operational limitations of supply vessels.

2.1.11 Operability

Early ship and barge-shaped MODUs were severely limited in performance if seas exceeded 3-4 m. Vessel motions and wave forces made it very difficult to work the units, and mooring equipment could not withstand the wave effects. The introduction of the semisubmersible hull form immediately improved the operability of the MODU, and modern severe - environment semisubmersibles suffer weather downtime less than 5% of the time during the year.

2.1.12 Deepwater Operations

Early units evolved from Gulf of Mexico practice where water depth seldom exceeded 100 m and seas were less than 2.5-3 m except during hurricanes. Designs were adapted to deeper water in stages, and MODUs can now operate in virtually any water depth, and in seas up to 20 m without leaving station. Semisubmersibles are now designed to withstand a maximum wave height in excess of 30 m in some regions, with an associated wind speed greater than 50 m/s.

2.1.13 Hostile Environments

Drillships and semisubmersibles have been used in ice covered areas during ice-free periods of the year. Most semisubmersibles have some form of ice protection at the transit waterline, but several drillships are ice strengthened at the operating waterline to protect the hulls against drifting ice. Further advancements are expected in design of ice-classed MODUs, and a circular hull unit has now been built for operation in first year level ice in the Beaufort Sea.

2.1.14 Dynamic Positioning

Prior to the introduction of dynamic positioning (DP) systems on MODUs, the maximum water depth for exploration drilling was approximately 365 m. With the refinement of DP systems, wells have now been drilled in water depth exceeding 1400 m and waterdepth up to 1830 m present no technical challenges.

2.2 SAFETY OF OPERATION

Safety aspects of modern MODUs are discussed in many references included in Part III - Section 8. The principal safety features of modern MODUs are discussed in Part II and summarized below:

2.2.1 Stability Requirements

Stability regulations now in effect for MODUs exert a strong influence on the configuration and size of the unit, and usually limit the payload capacity. The regulations are intended to ensure that a MODU can resist the effects of all expected storm conditions and survive the most likely damage situations without jeopardizing the safety of the personnel on board. The present regulations are designed to limit payload so that the effects of 50 m/s winds and waves, or damage flooding resulting from boat collisions do not capsize the unit.

2.2.2 Structural Adequacy

Present design practice incorporates basic considerations that enhance the structural adequacy of the MODU and the safety of personnel on the unit. These considerations include reasonable factors of safety for design loads, adequate fatigue life, redundant structure or reserve strength, ability to withstand low energy collisions, and selection of appropriate construction materials. In recent years technical advances have enabled engineers to improve their success in predicting maximum design loads and gain a better understanding of fatigue life of the structure.

Modern MODUs routinely withstand collisions with supply vessels with no significant damage to the structure. Vital elements of the structure are often made redundant or are provided with sufficient reserve strength to withstand credible loadings.

2.2.3 Ballast System

Ballast systems have evolved from simple gravity type systems to the present day multiple pump room fully redundant configuration. Ballasting is critical to all three types of MODU's covered in this study but the semisubmersible requires the most complex ballast system. Many of the most recent semisubmersible designs have four

pump rooms located fore and aft in each pontoon. This provides full redundancy as well as the capability of emergency deballasting in the event of accidental flooding. Controls include automatic fail-closed valves, valve status, and tank level indication systems.

2.2.4 Emergency Power System

All vital services are now directly connected to the emergency source of power. Some new MODU designs include emergency generators capable of operation at large angles of inclination, consistent with damage flooding requirements. This action ensures that the unit will be able to recover from most conditions of accidental flooding.

2.2.5 Inspection and Maintenance

Significant advances in design and construction technology have necessitated similar refinements in inspection and maintenance practices. While these aspects are operational factors rather than design factors, they bear a direct influence on the increased level of safety of modern MODUs. More sophisticated fabrication and testing techniques are employed today to detect and control fabrication flaws or deficiences. Modern MODUs are required by national regulations to attain various levels of fitness in order to be permitted to operate. Planned maintenance is being implemented on many MODUs as a means of reducing the costs of operation while increasing the unit's operating efficiency.

2.2.6 Lifesaving Appliances

The operators of MODUs are taking steps to improve designs of existing lifeboats and escape capsules. There have been significant advances from the early open boats to the totally enclosed, powered escape capsules, but even more development is needed. The principal objective of industry is the development of a boat or launching system which can be deployed in heavy weather from an inclined vessel. The industry is investigating novel designs for launching

systems including free-fall systems, pendulum type capsules, and escape slides. Many systems offer the promise of a breakthrough in personnel evacuation safety, both in the drilling industry and in other maritime industries.

2.3 AREAS FOR IMPROVEMENT

The main areas for potential improvement in the safety of MODU operations are discussed below.

2.3.1 Jack-up Seaworthiness

Although the overall MODU accident record has shown improvement over time the number of accidents involving jack-up units under tow or when moving on or off location points to an area for improvement. A reduction in the number of jack-up accidents is certainly desirable. Whether this is most easily achieved by better operational planning and weather forecasting or by design changes is arguable.

2.3.2 Lifesaving Appliances

Both the Alexander Kielland and the Ocean Ranger marine disasters have pointed out the difficulty of performing lifesaving operations from a disabled platform. Industry is moving forward with numerous innovative solutions to this problem of lifesaving operations. The increase in safety through improved lifesaving capabilities is of high priority for all concerned.

2.3.3 Ballast Systems

Performance requirements for MODU ballast systems need to be addressed to ensure that ballast control capability is available in emergency situations. As a minimum the ballast system should provide deballasting or counterballasting capability for damage or flooding conditions set forth in the regulations.

2.3.4 Training

Though not a design problem the issue of MODU crew training is certainly of importance in overall MODU safety. Many operators are moving forward with increasingly rigorous and comprehensive crew training programs. These programs often involve both the operations and design staff and simulators are now available for training is ballast control and BOP operations. The increase in feedback from operations to the designers will help make for safer design in the future.

2.3.5 Rules and Regulations

Present rules and regulations covering MODU design in harsh environments have proven to be adequate. There have been no compelling examples to indicate a major change in existing rules is necessary. The causes of the Alexander Kielland and Ocean Ranger MODU accidents have been attributed to lack of enforcement of existing classification society rules and to improper training of crews, but not specifically to inadequacies in existing regulations for MODUs. However, the variations in application of standards by regulatory bodies is sometimes confusing. There is a need for unification of current national regulations governing MODU design for harsh environments.

DRAFT

THE RISKS OF OFFSHORE OIL AND GAS EXPLORATORY DRILLING IN EASTERN CANADIAN WATERS

A Report to the Royal Commission
on the
Ocean Ranger Marine Disaster

Part One   A Perspective on Risk

Part Two   Risk Assessment of Human Safety

Ian Burton
Toronto
May 1984

I

THE PROBLEM OF RISK

For almost two decades the people of Atlantic Canada have been looking forward to the development of an offshore oil and gas industry that will bring to the region employment for the workers and a higher level of prosperity for all. It was understood from the outset that any such development involved some risk. Those who live close to the sea, and earn their livelihood from sea-going activities are no strangers to risk, and so the explorations that began in 1966 were undertaken in the knowledge that the sea is a dangerous place. Perhaps also there was some resigned or fatalistic acceptance of the risk.

Just how dangerous it can be was brought home dramatically to all Canadians on 15 February 1982 when the huge semi-submersible Ocean Ranger tilted and then capsized and sank to the bottom, with the loss of all 84 persons aboard. That event, as is a common experience following disasters, gave rise to a lot of searching questions. "Need it have happened?", "Could it have been prevented?", "How can we make sure it never happens again?" and, in terms particular to this case, "What are the risks of offshore oil and gas explorations off the coast of Canada?".

It is to this last question that this essay is addressed. Are the governments of Newfoundland and Labrador, Nova Scotia, and Canada and the people they represent sending offshore workers into situations that are too dangerous in the quest for the benefits of economic growth and development? How do we know that what governments and private corporations are asking

people to do is fair and reasonable? How can we be sure that appropriate steps have been taken to safeguard the lives of those who accept risky occupations for the benefit of the whole society?

It is not the purpose of this report to attempt definitive answers to such questions. Rather the objective in Part One is to try to clarify the concept of risk and the methods of risk analysis and risk assessment, in order to show how the problem of risk might ideally be approached. There are shortcomings in the methods and in the available data, as will be shown, but the primary aim here is to develop a reasoned approach to risk, and to place the risk of offshore oil explorations in some perspective. In Part Two an assessment of the risk is attempted, with comparisons provided of the risks of offshore drilling with other activities.

A questioning attitude to risk is a characteristic of the last decades of the twentieth century. As the second millenium draws to its close many more people are questioning, on a scale never before seen, the directions and values of western industrial society. These questions and this questioning attitude would have seemed strange to our forefathers who first settled and built Atlantic Canada. For them it was a case of "nothing ventured--nothing gained". To take risks was a way of life and while the value of skilled seamanship was a source of heroism and pride, the guidance and protection of the Hand of God was also often and earnestly sought. When things did go wrong and lives were lost people were often disposed to accept events as Acts of God and return with humility to their prayers and their boats.

What has happened to change all that? Has western society lost its nerve or its adventurous risk-taking spirit, that things are so much questioned? To the extent that this is true, it is probably due to success and affluence. The widespread concern with risk in Canada today extends to many aspects of life. Canadians are concerned about toxic contaminants in food and drinking water; about the transport of dangerous goods by road and rail; about the risks of nuclear power development; about the use of chemicals to control pests in forests and farms; and about the dangers of offshore oil and gas exploration. The list seems almost endless.

Reading our daily newspapers and watching television, a visitor from a distant country might be excused for thinking that Canada has become an extremely dangerous place where people are threatened by hazards on every side. The reverse is true. Life in Canada today is safer than it has ever been. The infant mortality rate is among the lowest in the world, and people live longer lives than in most other countries. If life is so risky, how is it that people are living longer? The truth is that life is not more risky for the average Canadian. The risks our forefathers took in developing the country, and the risks we have taken with modern technology and industry in recent decades have paid off. The wealth we have created has enabled us to reduce risks.

Of course, the type of risks we face has changed. The development of science and the application of technology have indeed created new risks that did not exist before. In general, however, the new risks have so far proved to be less serious than the old risks that we have managed to control and reduce. On balance development reduces risks. In the lives of nations as in the lives of people, richer means safer.

Paradoxically, it may be our very success in controlling risks, and guaranteeing a safer, richer and longer life for most Canadians that makes us fearful of the new and unfamiliar risks. It is not so surprising therefore that Canadians with a degree of material wealth and social security that is the envy of most of the world's people should have become fearful about the new risks they face, and even somewhat distrustful of those in authority who seek to provide reassurance and tell people that they need not be so concerned.

While it is true that Canadians are more fearful about risks than ever before, it is not always the case that those most at risk are the most concerned. Those that live close to nuclear generating stations have been shown in sample surveys to express less anxiety about the dangers of a nuclear accident than those living further away.(Whyte, 1983). Even in relation to toxic hazards, and transport risks, there is often a public interest group voicing opposition as loudly as or more loudly than those who are most at risk.(Whyte and Burton, 1982).

The concern for the dangers of offshore oil and gas explorations is another case in point. The concern for the safety of the workers, and perhaps especially for the possibility of environmental damage sometimes seems to be greater the further one gets away from the sea!

In some ways this is an encouraging sign of national maturity--when people are genuinely concerned for the welfare of all Canadians and all of the Canadian environment, wherever they may happen to live. No civilized nation in the latter part of this century would wish to be seen subjecting some of its citizens to an undue risk in order that others may benefit. The principles of fairness and equity in sharing benefits and risks have long

been established as a basis for our society, and the orderly conduct of our affairs is understood to require that all people, those with much power and responsibility, as well as those with little, approach such questions in an open-minded and reasonable fashion.

How, it might be asked, is reason to be brought to bear on such a complex matter as the risks of offshore oil and gas exploration? The answer is that new methods of analysis have been developed precisely for the purpose of handling such difficulties. Collectively called "risk assessment" these methods enable us to see what is at stake and what is involved when governments and private sector corporations embark upon new ventures in the application of science and technology for the benefit of society. This report describes some of the methods and characteristics of risk analysis especially in the context of the Eastern Canadian offshore explorations and indicates how they can be helpful now and may become more so in the future. At the outset it is also necessary to sound a note of caution. Risk analysis is not a panacea. It does not solve the problem of risk by providing a formula for decisions on the basis of quantitative analysis. What it can do is to provide perspective and facilitate choice. Ultimately the choices to be made require judgement, based on sound knowledge, sympathetic understanding, wisdom and a lot of common sense.

The beginning of wisdom in the study of risk is to realise that there is no such thing as "safe" if we mean by that some holy grail of <u>absolute</u> safety. Safe is a relative term. Any nation, just as any person, that is alert to the opportunities and dangers of this world, must realise that we can only hope to achieve a position that we can accept as "safe enough".

This does not mean "safe enough" for all time, but simply "safe enough" for now. What we consider tolerably safe today our children and grandchildren may not tomorrow. They will have to recognize, however, that risk is a part of life, and that living well and successfully means to choose your risks wisely. Excessive concern over the wrong risks does not lead to greater safety--it actually increases overall risk by leading to the neglect and exacerbation of other risks.

Two examples serve to illustrate the point.

Whan artificial sweeteners used in soft drinks--cyclamates--were withdrawn from the market because they were suspected of being carcinogenic, risk assessors pointed out that were consumers of soft drinks to substitute an equivalent amount of sugar in their diet, that this would contribute to obesity and heart disease. Calculations were made to show that the net effect on human health would be worse from consuming sugar than cyclamates. Thus an initial attempt at reducing risk by banning cyclamates could turn out to have quite the reverse effect.

Similarly in the case of energy production, opponents of nuclear power generation have pointed to the risk to human health of possible releases of ionizing radiation. If nuclear energy is not developed however, an expansion of fossil fuel (oil and coal) generating stations will be required with an associated increase in sulphur dioxide emissions causing acid rain. Evidence for the adverse health effects of acid rain is now beginning to appear, especially in the release of heavy metals into the environment. Here again, it is evident that well meaning attempts to reduce risk in one direction may increase them in another, and this can happen in quite unexpected ways.

In theory a balanced risk or minimum aggregate risk approach is desirable, but reliable comparisons of this kind are rarely possible. The lesson to be noted is that the apparent elimination of risks by banning cyclamates or stopping nuclear power development is not necessarily the safest course.

Not to take the risks of offshore oil and gas development could well prove to be the more risky course. But to take these risks in a careless fashion, putting those involved at too high a risk would also be, if done knowingly, an irresponsible act.

IX

CONCLUSIONS

1. The Data Situation

Risk analysis of offshore oil explorations by the historical method is severely handicapped by data limitations. These include:

i) the short period of record such that average rates are subject to wide variation as a result of the occurrence of a small number of rare events;

ii) incompleteness of reporting;

iii) systematic bias in figures reported to regulatory bodies and worker's compensation boards.

When cross national comparisons are made, these data limitations are further increased by lack of standard definitions and reporting classes.

If accident and fatality rates are considered to be important in Canada as a means of assessing risk, monitoring safety performance and providing comparable data, then a single accident reporting form collected by a single agency with the authority to ensure that the reports are complete and accurate would provide the information needed to gain better understanding of the causes of accidents and the risks faced by offshore workers. If such an innovation were made in addition to the existing reporting requirements for companies in the offshore industry, compliance would be less than enthusiastic and the results would correspondingly be likely to suffer. Improvement and simplification of existing reporting is what is required.

There is an important international aspect to data reporting. If data from the several nations engaged in offshore oil explorations are to be more comparable, some standardization of reporting categories and definitions is desirable. This is a task more appropriately undertaken by an international intergovernmental body such as the International Labour Organization.

2. The Risk of Fatality

Deaths in the offshore oil and gas industry can be divided into two populations. Those associated with routine operations are termed "industrial accidents". Those associated with major accidents are termed "marine disasters". Fatalities in the first category occur more often in small numbers--often as single fatalities and almost always in groups of less than 20 deaths at any one time. Fatalities in the second category are associated with a large number of simultaneous fatalities as in the case of the Alexander Kielland (North Sea) and the Ocean Ranger (Canadian east coast).

Marine disasters are associated with the total loss of a MODU. There have been 63 total losses reported in the period 1956-80 (see Table 4). Only a small number of these have resulted in a large loss of life.

Of the 486 lives lost worldwide in the period 1970-82, a total of 349 or 72% have been lost in the four major disasters listed in Table 6.

Let it be assumed that large losses of life may be expected at the rate of four times in every 63 total loss accidents, or once every 16 total loss accidents. If one total loss occurs for every 81.3 rig years (Table 4)

then it may be estimated that a total loss accident associated with a high loss of life--that is, a marine disaster, may be expected to occur once every 1,300 rig years. Given a record of 5,125 rig years of operation in 1956-80 (Table 4) four major loss of life accidents is close to the expected number.

How does this translate into expected risk of fatality for an offshore rig worker? If all persons on board a rig involved in a total loss accident are assumed to be lost (not likely to be always the case) then the chance of being killed for a person who spends a whole year on a rig is .0008, or 1 in 1,250. If the person (as is commonly the case) is on the rig only half of the time then the risk of being killed in any given year is .0004 or 1 in 2,500.

This compares with the probability of being killed of 1 in 166 calculated in Section IV on the basis of assuming that all total loss accidents involve the loss of all hands on board. Certainly this has been the limited Canadian experience. In 49 rig years of operations there has been one total loss accident and all lives were lost.

Estimates such as these demonstrate the twin difficulties, on the one hand, of extrapolating from a short period of record, and on the other hand, of applying worldwide data to eastern Canada offshore conditions. The risk estimate of a worker being killed in a single year of .006 made in Section IV is almost certainly too high. The risk estimate of .0004 is probably too low. Note that it is very close to the risk to the population of the United States from all accidents which is reported as 1 in 2,000 in Table 7. This would suggest that being a worker on an offshore rig is no more dangerous

than the life of an average person in the United States. This is a little hard to accept.

To say that the risk of fatality of an offshore oil rig worker in eastern Canada is (on an annual basis) between .006 and .0004 is not a very precise estimate. It is the most that can be said on the basis of present data.

Fatality rates for the United States, the United Kingdom and Norway are listed in Table 31. These rates are not strictly comparable, but what is surprising about them is the relatively narrow spread considering the data deficiencies. In probability terms the chance of being killed for an offshore worker ranges from .002 (U.K. 1974) to .00002 (U.S.A. 1979), not counting the record of zero fatalities in the U.K. in 1978.

3. Injury Rates

Accidental injuries can be compared less easily between countries than fatality rates. No injury rates have been found for U.S. offshore areas. Comparisons cannot be made with rates for the United Kingdom North Sea area which are given in "serious accidents per 1,000". The closest comparison that can be made is between eastern Canada and Norway as shown in Table 32. While the years for which data are available do not coincide (except for 1977 and 1978 for Norway and Nova Scotia) the Norwegian rates are generally of the same order as those in the eastern Canada offshore area.

This analysis has not been able to establish any major differences in injury rates among the four countries studied.

TABLE 31

COMPARATIVE FATALITY RATES IN OFFSHORE OIL ACTIVITIES IN THE UNITED STATES, THE UNITED KINGDOM AND NORWAY

Year	U.S.[1]	U.K.[2]	Norway[3]
1974	--	2.0	ranges
1975	--	1.5	between
1976	1.13	1.5	1.7 and 2.8
1977	.96	.8	
1978	.85	0	
1979	.62	--	

1. Rate per 1,000 workers per year.

2. Rate per 1,000 employed.

3. Rate per 1,000 person-years.

TABLE 32

INJURIES PER MILLION PERSON-HOURS. NORWAY AND EASTERN CANADA.

	Norway	Eastern Canada			
		Nova Scotia		Newfoundland and Labrador	
		Upper Estimate	Lower Estimate	Upper Estimate	Lower Estimate
1974	80	--	--	--	--
1975	55	--	--	--	--
1976	67	--	--	--	--
1977	75	74	148	--	--
1978	83	42	84	--	--
1979	--	99	198	23	46
1980	--	80	160	37	74
1981	--	20	40	27	54
1982	--	44	88	49	98
1983	--	--	--	53	106

Definitions as given in Tables 19, 27 and 30.

4. <u>Comparisons with other activities</u>

In the United Kingdom it is reported that an offshore worker is about twice as likely to have an accident as a worker in general manufacturing and about half as likely as a miner. Accidents offshore are more likely to be fatal especially in diving activities (Tables 13, 14, and 15). In Norway it is reported that the injury frequency on offshore platforms is comparable to landbased activities such as mining and wood-conversion. (Table 20). In the United States outer continental shelf it is reported that the <u>drilling</u> accident rate is nearly 15 percent lower for marine oil and gas operations than for those on land.

There is no statistical basis for similar comparisons in Canada without resort to inaccessible raw data. Such an analysis could, in theory at least, be made for Canada especially if accident reporting procedures are improved. Given that accident rates in the eastern Canada offshore area do not appear to be significantly different from those reported elsewhere, especially in Norway, there is no reason to suppose that comparisons with other industrial activities would show Canada's offshore oil explorations to be especially more dangerous from an "industrial accident" point of view. Indeed on the basis of limited comparisons it might be judged that offshore drilling and related activities are safer in terms of industrial rates and more dangerous only in terms of the low probability of a "marine disaster".

5. Accidents by Type of Activity

Priority areas for risk reduction can be identified by an examination of those types of offshore activity which result in higher numbers of accidents.

In the Gulf of Mexico it is reported that 42 per cent of the accidents involving fatalities occur in drilling operations, and a further 41 percent in production operations (Table 9). Most fatal accidents are caused by machine or equipment failure (27 per cent), personal accidents (24 per cent) and fires or explosions (19 percent). By comparison helicopter crashes account for only 17 percent of fatal accidents and blowout only 1 per cent.

In the United Kingdom sector of the North Sea, drilling is the single most accident related activity, and the largest number of fatalities is associated with diving (Table 11). There has been only one helicopter fatality reported.

In contrast, in the Norwegian sector of the North Sea, diving has a much lower proportion of fatalities, whereas helicopter accidents account for the largest single fatality class (Tables 17 and 18).

Why is it that in the Gulf of Mexico drilling appears to be more dangerous, and that diving appears to be a special problem for the British and helicopters for the Norwegians? The most likely explanation is that the differences are more apparent than real and are a product of limited periods of record. When experience is short one or two freak events can change the statistical pattern. Only with long time series data are these freak events averaged out into some "normal" rate.

6. Factors in Accident Events

Man-machine systems of all kinds can fail or can operate improperly due to faults in the machines and their design or due to operator-error (commonly called human errors). All accidents are due to human error at some point. Accidents resulting from equipment failure may be traced back to poor or improper design.

Experience shows that in the offshore oil and gas industry, the rapid expansion of the worldwide MODU fleet has been accompanied by substantial improvements in technology. Yet it is clear that things can still go radically wrong as demonstrated in the total loss accidents in recent years. The further application of risk modelling methods such as event- and fault-tree analysis to the design of offshore oil platforms may yield benefits in the prevention of future possible disasters.

The most common cause of accidents whether of the "marine disaster" or "industrial accident" type is operator error. The record shows that the safety record in the offshore oil and gas industry is as good if not better than in comparable industrial activities on land. Accidents at sea, however, are more likely to become serious because of the hostile marine environment in which they may occur. For this reason, a higher level of safety performance should be expected on drilling rigs at sea than on land. There is some evidence, in the United States at least, to suggest that a higher standard of performance is being achieved.

The United States NRC study (1981) makes one very telling point about offshore safety. It reports that operator experience is a key factor.

It was found that 76.5 per cent of all injuries occurred to employees with less than one year on the job, and that 54.8 per cent of all injuries occurred within the first six months of employment.

MODU workers who are in such danger of accident are necessarily a danger to others also. Clearly the proper selection and training of offshore oil workers is a crucial factor in improving safety performance.

In addition to the application of risk modelling and improved worker selection and training, this study of risk indicates that another area of risk reduction that needs close examination is the area called "consequence mitigation". It is an axiom of risk analysis that accidental events can be reduced in frequency but not completely eliminated. Risk management includes the making of preparations to help reduce the effects of accidents when they happen.

AN ESSAY ON THE DESIGN

OF

MOBILE OFFSHORE DRILLING UNITS

PREPARED FOR THE

ROYAL COMMISSION ON THE OCEAN RANGER

MARINE DISASTER

MAY 1984

EARL AND WRIGHT

CONSULTING ENGINEERS

I. INTRODUCTION

A. Purpose

This essay provides an overview of the design procedure for a Mobile Offshore Drilling Unit (MODU) from conceptual studies through rig operation. This procedure is shown in Figure 1. The information presented is based on the experience of Earl and Wright and its parent company, SEDCO, and does not necessarily represent an industry standard.

The following chapters outline design procedures applied by Earl and Wright in the design of SEDCO semi-submersible drilling units. The same general approach applies to drillships and jack-ups. However, the semi-submersible's unique structural arrangement presents special design considerations, and its fabrication is geared toward pressure vessel quality rather than the sometimes less stringent requirements normally applied to ships.

B. Design Timetable

The following description of the design process implies a well defined boundary between each phase and between the steps within each phase. In practice, time constraints often dictate an overlap between steps and phases. For example, construction of the basic structure may begin before all of the machinery and outfitting details are complete.

C. Participants and Responsibilities

Various participants are involved during the design process. Section 5 identifies the participants, summarizes their roles, and discusses their responsibilities and impact on the final product.

V. PARTICIPANTS/CASE STUDIES

A. Participants

The major participants in the design, construction and operation of an offshore drilling unit have direct impact on the unit at various times and in various capacities. The primary participants are the owner, designer, builder, drilling contractor, operator, classification society, and regulatory agency. One organization may fill more than one of these roles.

Due to the number of participants and the complexity of the overall process, it is easy to visualize breakdowns in communications and disagreements on interpretation of various technical or regulatory requirements.

These potential problems may be further compounded by the various combinations of participants. The following two examples highlight the potential discontinuities that can occur.

B. Case Study No. 1

The first example in Figure 6 represents an extreme but realistic situation which has numerous possible gaps or discontinuities in the design-construction-operation process. The basic assumptions are as follows:

- o The drilling rig is designed by an independent designer who has no further involvement with the construction, or operation of the unit.
- o Rights to the design are bought by a builder, who builds the rig on speculation.
- o The eventual owner buys the unit and obtains a certificate of fitness to operate in a jurisduction not covered during the design and construction of the unit.

- Subsequently, the owner leases the rig to the drilling contractor under a bareboat charter.

This scenario requires several independent parties to separately interpret technical data and drawings to properly build and operate the drilling rig.

C. Case Study No. 2

The second example in Figure 6 minimizes the possibilities of discontinuities in the design-construction-operation process. In this case:

- The owner, designer and drilling contractor are all the same organization and operations staff.

- The owner has a shipyard team that includes members of the design group.

- The unit is designed for specific operators, and the operators' input is included in the design of the unit.

- The vessel is classed and certified during design and construction to operate in the designated drilling jurisdiction.

In this scenario, a single group is responsible for design, construction and operation of the drilling rig.

D. Consequences and Responsibilities

The consequences of the discontinuities during design, building and operation of a drilling rig are difficult to evaluate; however, it is advantageous to have continuity from initiation of design through operation of the rig, as represented by Case Study No. 2.

The responsibility for each step in the overall process is also clearly delineated in Case Study No. 2 as opposed to Case Study No. 1.

The roles of the classification society and regulatory agency in establishing guidelines and minimum standards of design construction and operation, and their participation in design review, building inspection and ongoing operations surveillance, are clearly understood. However, their responsibilities in case of a faulty design, defective construction or negligent operations (whether implied or actual), have not been addressed to date.

MOBILE OFFSHORE DRILLING UNIT
Design, Construction, and Operations

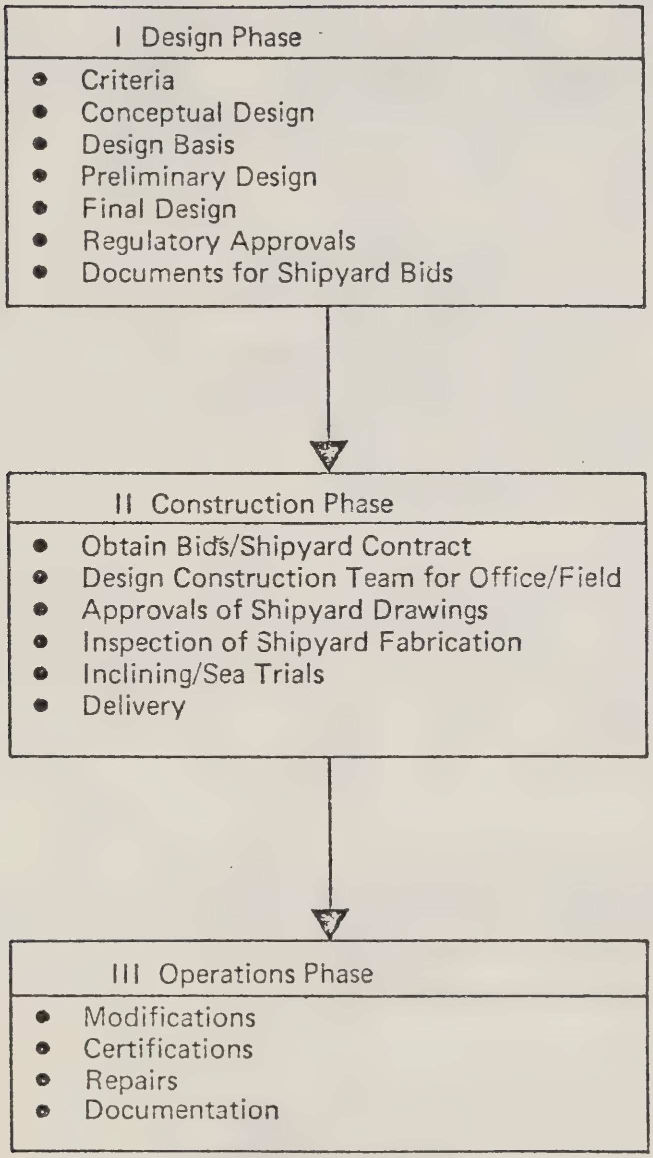


Figure 1

MOBILE OFFSHORE DRILLING UNIT
Conceptual Phase

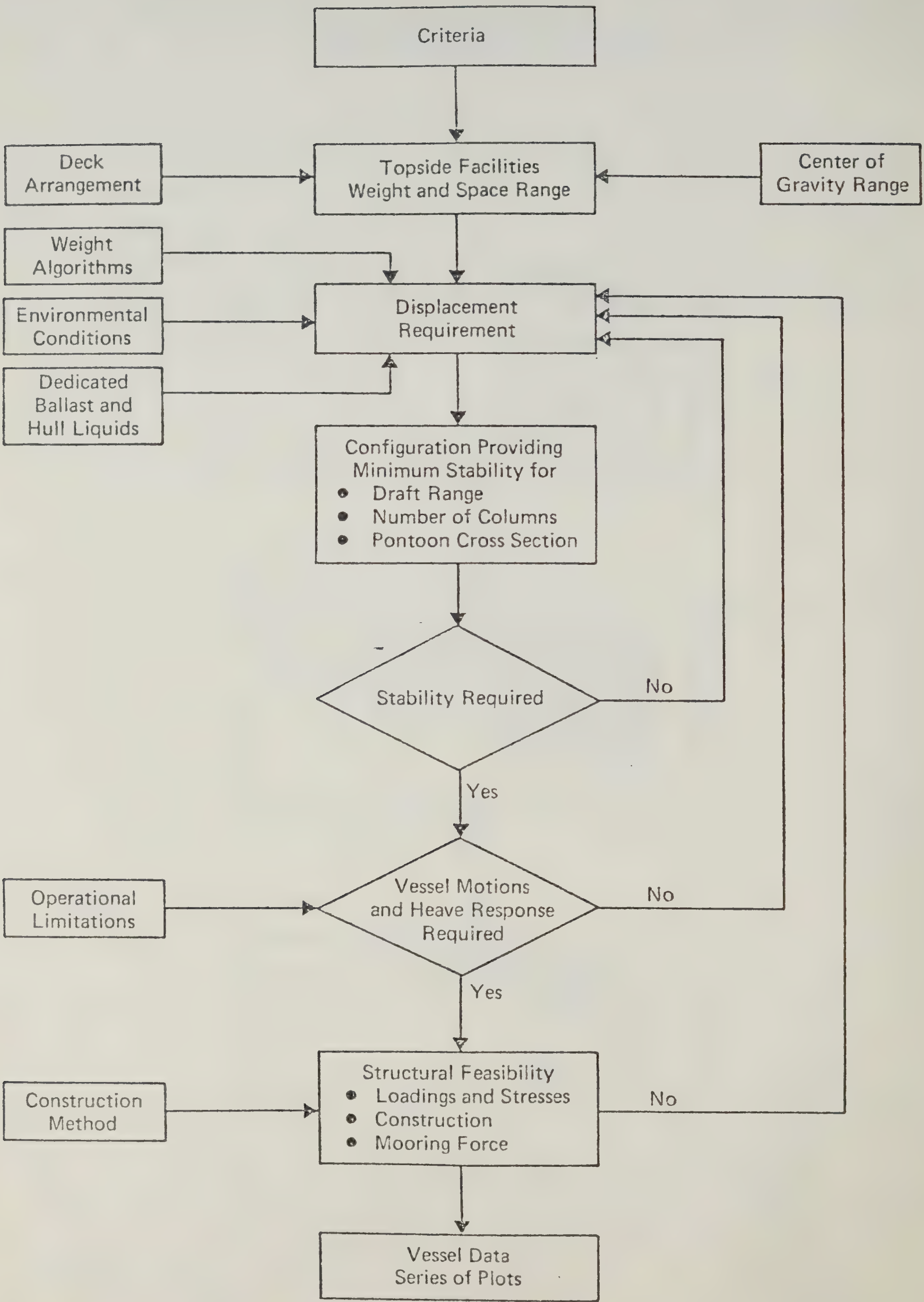


Figure 2

MOBILE OFFSHORE DRILLING UNIT
DESIGN PHASE

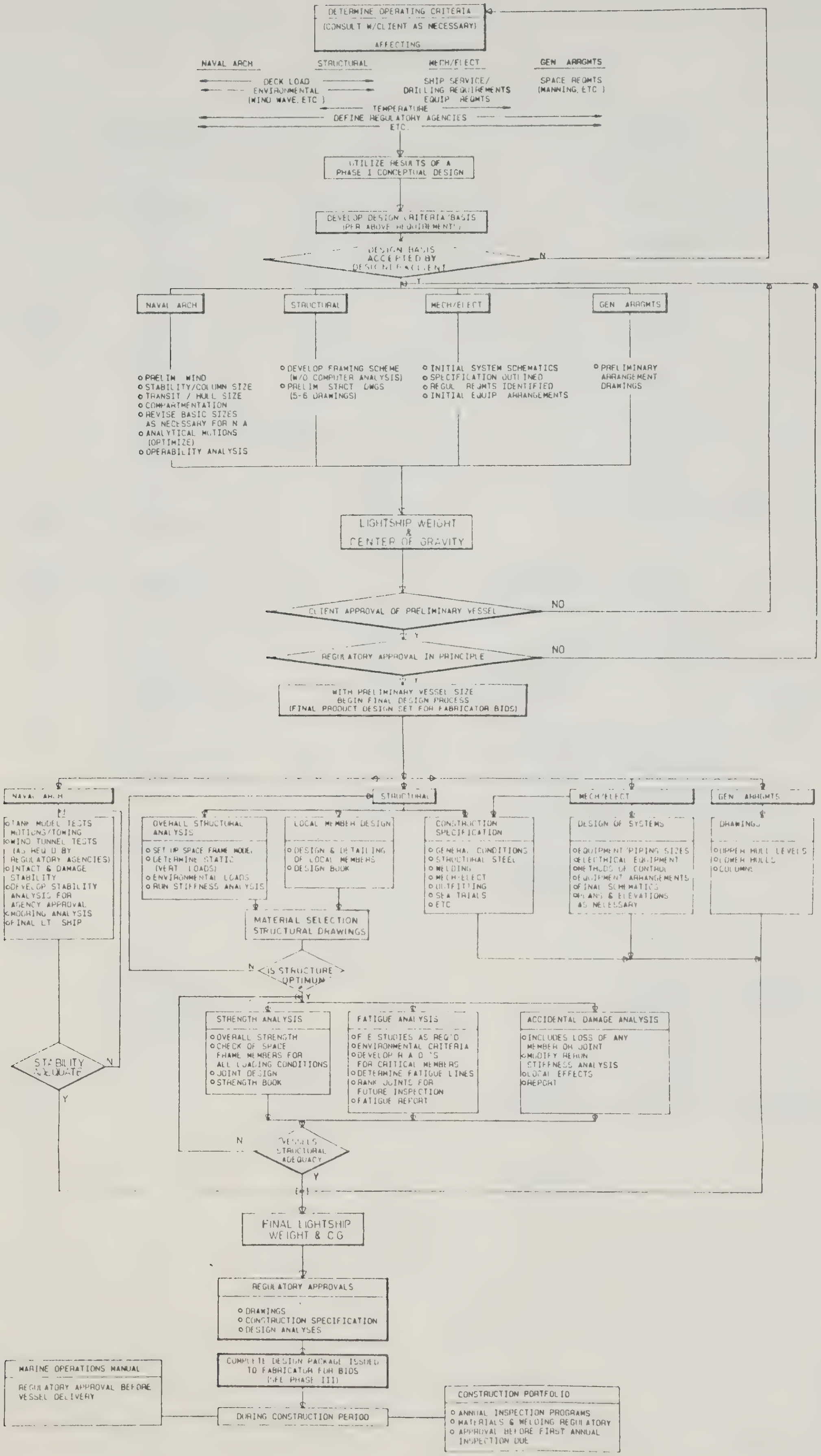


Figure 3

MOBILE OFFSHORE DRILLING UNIT
CONSTRUCTION PHASE

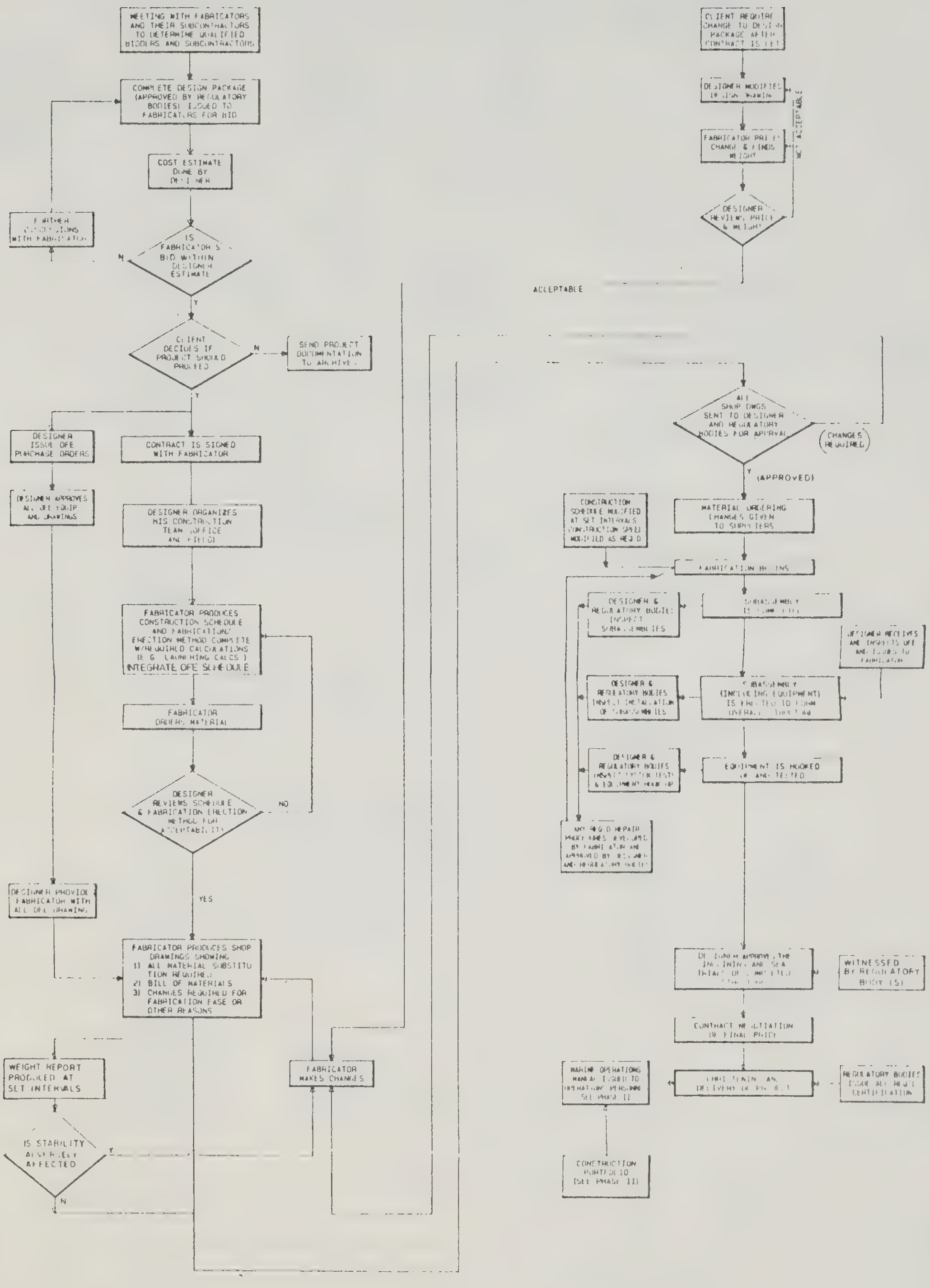
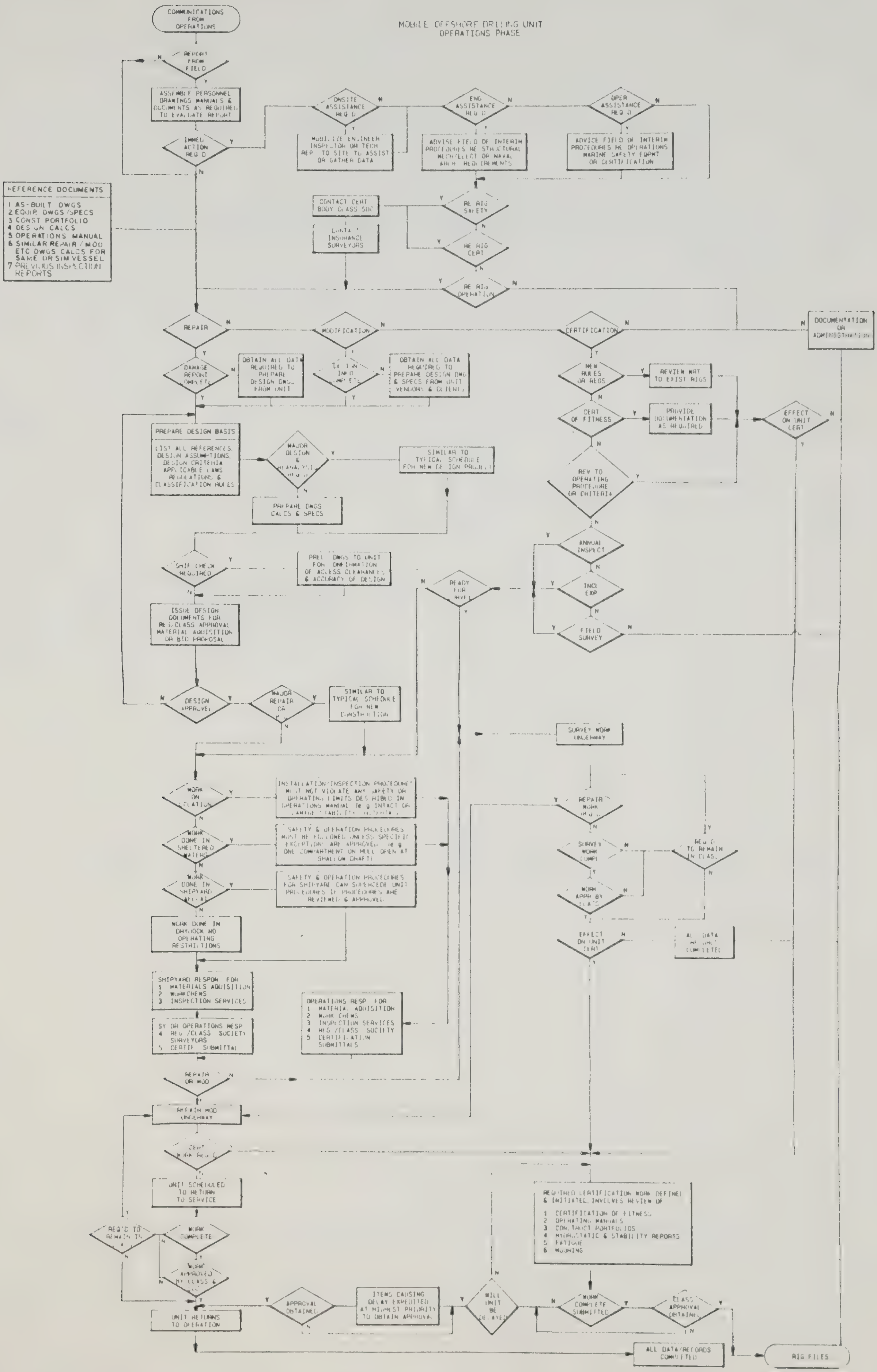


Figure 4



MOBILE OFFSHORE DRILLING UNIT
OPERATIONS PHASE
COMMUNICATIONS FROM OPERATIONS
REPORT FROM FIELD
ASSEMBLE PERSONNEL DRAWINGS MANUALS & DOCUMENTS AS REQUIRED TO EVALUATE REPORT
IMMED ACTION REQ'D
ONSITE ASSISTANCE REQ'D
ENG ASSISTANCE REQ'D
OPER ASSISTANCE REQ'D
ADVISE FIELD OF INTERIM PROCEDURES RE STRUCTURAL MECH/ELECT OR NAVAL ARCH REQUIREMENTS
ADVICE FIELD OF INTERIM PROCEDURES RE OPERATIONS MARINE SAFETY EQPMT OR CERTIFICATION
REFERENCE DOCUMENTS
1 AS-BUILT DWGS
2 EQUIP DWGS/SPECS
3 CONST PORTFOLIO
4 DESIGN CALCS
5 OPERATIONS MANUAL
6 SIMILAR REPAIR/MOD ETC DWGS CALCS FOR SAME OR SIM VESSEL
7 PREVIOUS INSPECTION REPORTS
CONTACT CERT BODY CLASS SOC
RE RIG SAFETY
RE RIG CERT
RE RIG OPERATION
REPAIR
MODIFICATION
CERTIFICATION
DOCUMENTATION OR ADMINISTRATION
DAMAGE REPORT COMPLETE
NEW RULES OR REGS
REVIEW WRT TO EXIST RIGS
CERT OF FITNESS
PROVIDE DOCUMENTATION AS REQUIRED
EFFECT ON UNIT CERT
PREPARE DESIGN BASIS
LIST ALL REFERENCES, DESIGN ASSUMPTIONS, DESIGN CRITERIA APPLICABLE LAWS REGULATIONS & CLASSIFICATION RULES
PREPARE DWGS CALCS & SPECS
ANNUAL INSPECT
INCL EXP
FIELD SURVEY
ISSUE DESIGN DOCUMENTS FOR REG/CLASS APPROVAL MATERIAL AQUISITION OR BID PROPOSAL
DESIGN APPROVED
SIMILAR TO TYPICAL SCHEDULE FOR NEW CONSTRUCTION
SURVEY WORK UNDERWAY
WORK DONE IN DRYDOCK NO OPERATING RESTRICTIONS
SHIPYARD RESPON FOR
1 MATERIALS AQUISITION
2 WORKCREWS
3 INSPECTION SERVICES
WORK COMPLETE
UNIT SCHEDULED TO RETURN TO SERVICE
REQUIRED CERTIFICATION WORK DEFINED & INITIATED, INVOLVES REVIEW OF
1 CERTIFICATION OF FITNESS
2 OPERATING MANUALS
3 CONSTRUCT PORTFOLIOS
4 HYDROSTATIC & STABILITY REPORTS
5 FATIGUE
6 MOORING
APPROVAL OBTAINED
ITEMS CAUSING DELAY EXPEDITED AT HIGHEST PRIORITY TO OBTAIN APPROVAL
WILL UNIT BE DELAYED
UNIT RETURNS TO OPERATION
ALL DATA/RECORDS COMPILED
RIG FILES

Figure 5

Figure 6

Case Study No. 1

	Owner	Designer	Builder	Drilling Contractor	Operator	Class	Reg
Concept	X				X		
Design		X				X	X[3]
Build			X			X	X[3]
Drilling	X[1]			X	X		X[3]
Maintenance				X		X	
Repair				X		X	
Modification	X	X[2]				X	X[3]

1. Bareboat charter to drilling contractor.
2. May not be the original designer.
3. May be more than one regulatory agency

Case Study No. 2

	Owner[1]	Designer	Builder	Drilling Contractor	Operater	Class	Reg
Concept	X				X		X
Design	X	X		X	X[3]	X	X
Build	X[2]	X[2]	X	X		X	X
Drilling	X			X	X		X
Maintenance	X	X		X		X	
Repair	X	X		X		X	
Modification	X	X		X		X	X

1. Owner, designer, and drilling contractor are the same organization.
2. Owner has shipyard team.
3. Unit designed for specific operators.

MARINE AND SAFETY TRAINING IN THE EASTERN CANADIAN OFFSHORE PETROLEUM INDUSTRY

EXECUTIVE SUMMARY

PREPARED BY:

THE COLLEGE OF FISHERIES, NAVIGATION, MARINE ENGINEERING AND ELECTRONICS

ST JOHN'S, NEWFOUNDLAND

MAY 1984

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EXECUTIVE SUMMARY

ACKNOWLEDGEMENTS

The College gratefully acknowledges the help and assistance of the Commission Staff in conducting this study. Thanks are also due to all those who assisted the study team by supplying information and demonstrating facilities. The study team - Jack Strong, Donald Williamson, David Bazeley and Sydney Hynes - was directed by Dr C R Barrett, the President of the College.

This summary of the report and its conclusions was prepared by Hollobone, Hibbert and Associates, London, England.

1. INTRODUCTION

The Royal Commission on the Ocean Ranger Marine Disaster as part of one of its terms of reference, to investigate training, certification and safety of persons on Mobile Offshore Drilling Units (MODUs) and their support craft, commissioned the College of Fisheries, Navigation, Marine Engineering and Electronics, St John's, Newfoundland, to carry out a study on training for the Eastern Canadian Offshore Petroleum Industry.

The objectives of the study were:

to describe and compare training practices in Canada and other countries,

to assess the adequacy of current practices and draw conclusions as to any outstanding needs for the training of personnel working in the Eastern Canadian offshore industry.

These objectives were considered in relation to four major aspects of the industry:

i) the training of all personnel in safety and survival;

ii) the additional specialist training required by persons with designated safety responsibility in an emergency;

iii) the training needed by persons over and above their normal industrial, marine or aviation vocational training, to enable them to work safely on a MODU or its support craft;

iv) the training of marine and aviation personnel in rendering assistance following an incident.

The area of concern was the Eastern Canadian Continental Shelf, from the Canadian/United States boundary North to approximately 75°N, and the scope was restricted to the exploration drilling phase and related support by vessel and helicopter. Training in other countries was also examined as a comparison with Canadian practices and to see to what extent existing international standards on foreign drilling units and support vessels working off Eastern Canada could be accepted as satisfactory Canadian requirements.

It is important to note that all the data used in the report were collected prior to the end of spring 1983. Improvements have been made over the past year in the areas of marine survival and safety training for the Eastern Canadian offshore petroleum industry.

2. STUDY STRATEGY

A study group of three researchers, under the general direction of Dr C R Barrett, President of the College, prepared the report.

Between October 1982 and April 1983, the team visited 73 organizations in Canada, the United States, the United Kingdom, Norway and the Netherlands. They also made literature searches and obtained information from another 22 organizations by telephone and 14 by mail.

The organizations selected for visit were government agencies, marine and petroleum industry training establishments, oil companies, drilling and services companies and search and rescue organizations.

In many cases the information obtained was of a subjective nature. Only Norway has detailed requirements for much of the training laid down in legislation. Industry standards are variable and are applied by the will of the industry, rather than as a requirement. Likewise training and certification differs widely between the long established marine training and the much more recently established MODU training.

3. AN OVERVIEW OF TRAINING

The reasons for training are discussed in the report. Industry and marine training can enhance a person's work skills and be tested in the workplace. Emergency training can only be tested in a real situation.

Training is available onshore in classrooms, on simulators or at practical training grounds using real equipment such as life saving or fire fighting equipment. It can also be done offshore as on-the-job training. While industry accepts the former, particularly for emergency training, there is still a strong feeling that 'real' practice must take place at the work site.

The four countries studied, the US, Norway, the UK and Canada, display a diversity of training approaches, and very different funding practices, ranging from the Norwegian belief that society as a whole must accept the responsibility to the US system where industry or the individual must be responsible for both provision and funding (even though Government may make a requirement). The UK and Canada fall somewhere in between these extremes.

USA

In the USA, industry is largely self-regulating. Government sets requirements for certain key figures in respect of certification - such as the person in charge of various types of MODU, or for specialist qualifications - for instance well control certification at various grades for drilling personnel. In general however there are few Governmental requirements, and none for basic safety training.

Training establishments are usually privately owned and funded from course fees. Some universities, notably the University of Texas, which collaborates closely with the International

Association of Drilling Contractors (IADC), play their part, but even then funding is directly from course fees and sale of publications.

Norway

In Norway, courses have been established in conjunction with existing marine or technical colleges. The Norwegian Operators' Association (NIFO), has funded specialist facilities, notably the very expensive ($6 million) fire ground and survival craft platform at the Norwegian Academy of Sea Rescue and Damage Control. Other maritime schools have received funds to set up special courses from companies with bases in their area.

Both vocational and safety training courses must be approved by the education authorities and the regulatory agencies. Generally there are no fees payable by those attending such courses, which are financed from central Government funding.

The United Kingdom

In the United Kingdom, much of the training effort revolves around the Offshore Petroleum Industry Training Board (OPITB), which was set up by the Government and funded by a levy on the industry. When Government support for training boards was withdrawn, the OPITB was 'adopted' by industry which injected an initial capital sum. Funding is now from course fees. It is managed by a Board comprising members from industry, trade unions and educational institutions. It offers training itself and works in conjunction with two non-profit making regional bodies, the Scottish Offshore Training Association (SCOTA) and the Petroleum Training Association North Sea (PETANS), whose members include all offshore companies in their respective areas (Scotland and East Anglia). They arrange training courses as requested by their members.

Two major educational establishments provide a great deal of the UK safety and survival training - Robert Gordon's Institute of Technology in Aberdeen and the College of of Further Education in Lowestoft. There are commercial schools offering specialist training in, for instance, offshore crane operation and drilling.

Canada

In Canada, the Petroleum Industry Training Service (PITS), an industry-governed non-profit making organization, has provided onshore drilling training since 1949 and is now becoming involved in offshore matters.

The Canadian Oil and Gas Drilling Regulations and Canadian Shipping Act require emergency training for offshore workers, as do the Newfoundland and Labrador provincial government regulations. The Canadian Ministry of Transport's Marine Emergency Duties Course, MED II, is available at public educational establishments in Canada. In Newfoundland and Nova Scotia special courses have been developed for MODU workers. There is no mandatory standard for safety training in the Eastern Canadian offshore.

Newfoundland and Labrador Petroleum Regulations (1977) require from the industry some expenditure on research, development, education and training, but only a small proportion had been spent on training by the end of 1982.

4. THE MOBILE OFFSHORE UNIT (MODU)

Types of MODU and Associated Hazards

The report considers the three basic types of MODU: jack-ups, semi-submersibles and drillships and discusses their advantages and disadvantages.

Industrial hazards include fire, blow-out, H_2S emission and accidents to persons caused by work activities. Marine hazards include bad weather, particularly violent storms, ballasting, jacking up or down, towing and other rig movement activities, structural or stability failure, instability of the seabed under a jack-up leg, collision with vessels, icebergs or pack ice and helicopter crash.

MODU Crew

The composition and structure of the marine crew varies on different MODU types and depends on national practices.

Drillships have fully certified officers and trained seamen, as required by the flag of registry. Standards between countries are very similar.

Semi-submersibles exhibit the greatest variation in manning. For units registered in Norway, the United Kingdom and Canada, manning scales are set by the marine administrations, and require certified officers and seamen, even while on station. Norway requires the Master, Mate (known as the Stability Section Leader) and Watchstanders to have special training in MODU operation, in addition to their conventional marine training. US registered semi-submersibles only require certified crew for long voyages, and only then if self-propelled. However, the US substitute key marine crew who have qualified for 'special industrial' certificates.

Jack-ups usually have only the barest skeleton marine crew on board when on station. There are no Canadian registered jack-ups, at present.

For Norwegian and British jack-ups the maritime administrations determine crewing levels on an individual basis. If self-propelled, they would probably be required to have a full complement of deck and engineering officers and seamen.

The composition of the drilling crew is similar for all MODU types regardless of flag. The drilling crew is divided into two 'tours', who work in twelve hour shifts. They are supported by various specialist service personnel and are usually directed by a representative of the lease operator.

Basic Emergency Training

The USA has no requirement for basic emergency training, although some companies provide on board instruction. Norway, the UK and Canada all require such training. The first two countries have agreed standards: in the UK, the UKOOA Guidelines, drawn up by industry to satisfy a legal requirement that all persons shall be suitably trained; in Norway the LEIRO II syllabus, required by law. The standards are comparable, with two-week long courses for each, but for classes of occasional offshore worker, the UKOOA Guidelines allow for various lesser grades of training.

In Canada, the Newfoundland Petroleum Directorate requires workers to go through the MED II course, which was designed by the Canadian MOT for mariners, or an acceptable equivalent. Both the East Coast and Arctic Petroleum Operators Associations (EPOA/APOA) and the Newfoundland Offshore Petroleum Impact Committee have made proposals, which are being implemented. The EPOA/APOA proposed Basic Offshore Training (BOT) course offers four levels of training, to satisfy the need to train various classes of

occasional visitor as well as regular workers. The Newfoundland Basic Offshore Survival Training (BOST) proposal is comprehensive and the format, two separate weeks, is designed to fit in with offshore work patterns. Two schools in Eastern Canada are equipped to provide the necessary training for the immediate future.

Conclusions on Basic Safety Training

General:

1. Norway, the UK and Canada all require some basic safety training. This training is not required in the US.

2. In Norway the standards are laid down by government, in the UK the industry has established standards through the UK Offshore Operators Association, to meet a general government requirement. In Canada, the National and Provincial Governments set standards, accepting equivalents.

3. The standards in the UK and Norway are similar to those in Newfoundland (BOST), with permanent offshore workers spending about two weeks on accident and fire prevention, fire fighting, first aid, survival craft operation, water survival and helicopter under escape.

4. The EPOA/APOA BOT involves five days training for regular offshore workers. There are three levels of lesser training for grades of casual worker. Conditions are comparatively benign off Nova Scotia. Newfoundland, where conditions are worse, does not accept BOT.

5. The North Sea countries have an adequate number of well equipped training centres (there may be some shortages at times of peak demand).

Training needs in Canada:

1. There is a need for persons on MODUs off Eastern Canada to have basic emergency training, appropriate to the harsh environmental conditions.

2. The content of a suitable course should comprise two main core components, namely: Offshore Hazards, Fire Prevention and Control; and Rig Abandonment, Rescue and Survival, to be taken by all regular workers. The course should be supplemented by lectures, demonstrations and hands-on experience in Helicopter Procedures; Cardiopulmonary Resusitation (CPR); Emergency Safety Oriented First Aid (SOFA); and Hypothermia, to be taken by selected persons.

3. The MED II standard required by the national Government is not specific to MODUs. The EPOA/APOA BOT and Newfoundland BOST, are designed for MODUs. Comparison between these and the Norwegian and British curricula would assist in devising the optimum course.

4. It is necessary to have different categories of training for persons spending different amounts of time offshore.

5. Categories could be:

Occasional workers	(up to three or four visits with no over-night stays)
Seasonal workers	(up to twelve nights per year offshore)
Regular workers	(over twelve nights per year offshore).

6. Training should be given in procedures to all who may have occasion to use radios.

7. Consideration should be given to harmonizing training standards throughout the region, taking due account of the different environmental conditions.

8. A review should be made of the facilities in the existing training establishments to ensure that they are adequately equipped and staffed to provide training for expected numbers of trainees.

Specialist Emergency Training

There are few formal requirements for specialist emergency personnel. In the US the only requirement is to have a number of certified lifeboatmen; in the UK and Norway, the requirements are ill-defined, although in practice training is usually given to fire teams and lifeboat coxswains. A number of schools offer suitable courses, for individuals and complete teams. In Canada, COGLA requires by directive that the crew has sufficient damage control training and this involves a demonstration of the damage control team at work.

Conclusion on Specialist Emergency Training

General:

1. No country has sufficiently addressed the subject of specialist emergency training, although in Norway and the UK numerous courses are available and are used by industry.

2. Some individuals, such as lifeboat coxswains and some groups, such as fire and damage control teams, need specialist training. General safety training does not sufficiently address specialist needs.

3. Where training is provided it is generally thorough and realistically simulates actual emergency conditions.

Canadian needs:

1. The isolated, distant nature of the industry makes self-help emergency action particularly important for the region.

2. Little emergency team or specialist training is available in Canada, and facilities need to be developed, probably at existing institutions offering basic safety training.

3. Subjects to be covered should include damage control, team and specialist fire fighting, man overboard and survival craft handling.

4. Conditions must accurately simulate those found in service and training exercises must be carried out in the most severe conditions practicable without hazarding the trainees.

5. Regular drills and periods of refresher training are needed by specialists to keep them in preparation for an emergency.

Marine Crew Training

The practices differ between the US, which tends to regard a MODU as an industrial site in the sea and Norway, the UK and Canada which regard it as a ship engaged in an industrial activity and require some marine officers and deckhands. In the US special industrial licences have been developed, to allow drilling or other industrial personnel to assume positions of command or other responsibility. These require proof of considerable practical experience in marine or offshore operations and an examination in marine subjects, which is not so rigorous. The other countries require certificated mariners. In Norway MODU experience and additional training is required for senior personnel, usually on top of their conventional marine training.

Certain key positions relating to marine operations from a MODU, such as dynamic positioning equipment (DP) operator and ballast control room operator have no direct counterparts, although simular marine tasks exist on ships.

Only Norway has addressed the problem of their experience and qualification, and then only for ballast controllers.

Conclusions on Marine Crew Training:

Person in Charge:

General:

1. The Person in Charge must fully appreciate the relationship between drilling activities and the capabilities and limitations of the unit.

2. Neither a Master Mariner nor a Toolpusher can be assumed to have all of the necessary knowledge and appreciation to command a MODU without specific training (however obtained) directed towards operations of the MODU type concerned.

3. Canada has, at present, no system for conducting, approving or certifying either MODU-related training for Masters or marine training for Toolpushers.

4. THE USCG Special Industrial Master's Licence, while offering a conceptual model, does not require sufficient depth of knowledge for safe operation in the harsh Eastern Canadian marine area.

Canadian needs:

1. Consideration should be given to establishing a course, to familiarize licensed Masters with the special aspects of MODUs and drilling operations. The course could lead to a 'MODU Masters' endorsement.

2. For jack-up units on station, the toolpusher could appropriately be the person in charge. A course should be developed to provide such a person with suitable familiarization with Eastern Canadian offshore conditions and provide training in marine emergencies.

Mates:

General:

1. Canada has no system for conducting, approving or certifying specific training for MODU Mates. The only domestic unit to date is crewed by Mates holding marine certificates. The MODU-specific training on this unit is organized by the operator.

2. A Mate on a MODU on location has only some of the duties of a merchant vessel Mate, but he has some additional duties which are unique to the job. The USCG Special Industrial Mate's Licence is designed to provide the necessary training for all of these duties, However the examination standard is low compared to regular marine certificates, but may be satisfactory for the sheltered waters of the Gulf of Mexico.

3. Standard marine training is a good foundation for the training of MODU Mates, although it does not address the special features of MODUs. The Norwegian MODU Stability Section Leader certificate course supplies the additional training.

Canadian needs:

1. Company MODU training for Mates would be appropriate but there are few suitable positions available where

practical experience in a junior capacity can be obtained.

2. Since the Mate is a central figure in an emergency on board he should be trained to an advanced standard in fire fighting, damage control, man overboard and the deployment of survival craft.

Watchstanders:

General:

1. The Watchstander has a central role in the operational marine safety of semi-submersibles, particularly in respect of ballast control functions. On most units, he has other duties as well, which are often similar to those of a marine watchkeeper.

2. There are as yet no widely accepted standards in Watchstander's training. Only Norway has any formalized program. Elsewhere there has been a great deal of recent activity in developing new courses, many directed to the stability of semi-submersibles. This is a necessary part of a Watchstander's training but is not in itself sufficient.

3. Watchkeepers on drillships are certified mariners. Their duties are consistent with normal marine practice and are adequately covered by regular training programs. There is no equivalent position on jack-up units except during moves, when normal towing practices are followed. These are adequate.

4. Canada has no published standards for Watchstander's training for domestic or foreign units on the Continental Shelf.

Canadian needs:

1. Watchstander's training should include: stability of multihull MODUs both when intact and damaged, ballasting procedures in the event of damage or loss of the main control system as well as the effects of anchor tension on stability and trim of MODUs, and other aspects of his duties as required. The Watchkeeping Mate certificate would be a good basis on which to develop courses.

2. Watchstander's training should include some instruction on the actual unit's system. Consideration could be given to independent examination of his knowledge.

Engineers:

General:

1. In Canada, there is a general shortage of persons holding a First Class Engineer's Certificate.

2. In Canada, there are no specific MODU related training course or examinations for engineers on MODUs under CCG regulations.

3. The Engineer is a senior person whose expertise is critical in times of emergency involving mechanical and electrical breakdowns and malfunctions.

4. Current examination standards to normal First or Second Class marine certificate levels, or their equivalent appear adequate.

The USCG MODU Engineers examination is of a lower standard, and may not be appropriate in Eastern Canada.

5. Norway is the only country which requires a licenced engineer (or equivalent) to take special MODU endorsement courses in addition to Marine Engineer Officer Training. The Norwegian Technical Section Leader's certificate is issued after succesful completion of this additional training.

Canadian needs:

1. Consideration should be given to setting up a course to enable suitably qualified engineers (not necessarily marine) to understand all the requirements of MODU machinery and systems. This could be used as the basis of 'MODU engineer' certification.

Radio Operators:

1. The Certificate required by a MODU Radio Operator is based on the marine radio equipment fitted where the unit is classed as a ship.

2. The present restricted radiotelephone operator's certificate does not itself indicate a sufficient level of competency to be radio operator on a MODU. It can be satisfactory if the employer provides adequate supplementary training in the operation of specially installed equipment and in company and other emergency procedures.

3. Where the MODU carries operators with marine certificates higher than the restricted radiotelephone operator's certificate, the training is adequate.

The earth station endorsement proposed by the DOC/CCG task force would be beneficial where the MODU is equipped with a satellite communications system.

Crane Operators:

General:

1. Crane operations, if not properly conducted, can pose considerable hazards to the MODU or to an associated vessel.

2. In Canada, there are no regulations requiring training or certification of offshore crane operators, nor are there any specifically organized courses for crane operators.

3. In Europe and the US, crane operator courses are available and on the job tutoring is also common. US training is usually on the job with packaged instruction and theoretical courses.

Canadian needs:

1. Consideration should be given to establishing a facility for realistic offshore crane training in Eastern Canada.

Helicopter Landing Officers:

General:

1. The position of HLO is not officially recognized on most units operating off Canada, and is not filled by any particular class of crew member.

No specific training takes place other than that obtainable on the job.

2. In a complex and potentially hazardous situation, the presence of a trained person, able to understand the sequence of events and react to any incident, is essential.

Canadian needs:

1. A committee, comprising helicopter operators, MODU owners and government, should be set up to consider existing European training courses, with a view to requiring similar training in Canada.

DP Operators:

General:

1. Good on the job training can be adequate, if subject to management commitment and control, except for emergency actions which need to be rehearsed under simulated conditions.

2. Simulator training is the only practical way to practise emergency actions, and if realistic is adequate.

Canadian needs:

1. Consideration should be given to the establishment of a suitable course, and the provision of simulator facilities. This may not be necessary if DP equipment suppliers can provide adequate training.

Weather and Iceberg Observers:

1. The training of Observers appears to be adequate for their tasks.

2. The policy of new Observers being accompanied by experienced personnel is a good safeguard, as well as providing for on the job training after the initial onshore courses.

Drilling Crew Training

Only Norway has a comprehensive training scheme for drilling personnel, which is orientated towards offshore. It was designed originally to build up a national drilling capability. The other administrations all require blow-out prevention (well control) training for key drilling personnel and in the case of the US all drilling personnel. Although this well control training is not specific to offshore and is not additional to the normal requirements for onshore drilling, because of the special hazards of a blow-out in the confines of a MODU out at sea, the requirements are briefly discussed in the main report.

In Norway training and certification is mandatory for the sub sea engineer, responsible for the sub sea BOP.

Conclusions on Key Drilling Crew Training

General:

1. Most countries require well control training, at least for key personnel.

2. Apart from what is done in Norway there are few comprehensive requirements for training of drilling personnel in their routine work skills.

Canadian needs:

1. Adequate well control training is necessary for all key offshore drilling personnel. It should include instruction on the sub sea BOP, unless in the case of a jack-up, this is not used.

2. Sub sea engineers need to be well trained in the use and maintenance of the sub sea BOP.

3. There are adequate facilities for drilling training in Canada, but there is a need for consultation between Government, industry and the educational sector to make the best use of them, for specialist offshore training.

4. Reciprocal acceptance of Canadian well control certification with that of other countries should be sought. Due to the nomadic nature of the industry it is a great advantage if drilling personnel can operate in other countries without re-certification.

5. MARINE SUPPORT

Without marine support, the offshore industry could not function. Offshore support vessels have been developed which are large, powerful and equipped with sophisticated control or even dynamic positioning systems.

Support vessels perform a number of roles: they supply the MODUs, carry diving support systems, are used for handling MODU anchors and for diverting approaching icebergs away from MODUs. In some offshore areas there are also dedicated standby vessels, ready to rescue persons who fall into the sea from MODUs.

The normal maritime training of officers and seamen, while adequate for general aspects of marine duties, does not cover the specialized aspects of marine support. Any additional training needs to be specific to the particular support task, and must be realistic using the actual (or similar) equipment on the support vessel.

Much of the training need not be regulated if acceptable guidelines can be developed, are followed and can be monitored. All training should be designed to bring confidence to the trainee and this can be achieved if training is practical and taught on the type of equipment in actual use.

Safety training is rarely tested in practice and regular drills and refresher training are needed so it is not forgotten.

The crews of standby/rescue vessels, in addition to their normal seamen's skills, need specialist knowledge. In particular the crews of fast rescue boats need regular training and practice, but all crew members must be trained to recover and launch the fast rescue boats, to recover survivors from the water, and give initial treatment for hypothermia and drowning. There should be flexibility, permitting a wide range of interchangeability

Conclusions on Marine Support Training:

1. Masters and Mates of support vessels, in addition to their marine certification and experience, need training in some or all of the following topics, depending on the type of vessel on which they are employed:

   characteristics of construction, stability, seakeeping, ballasting and cargo carrying arrangements of the specialized vessel;

   ship handling and holding station by means of twin propellors, twin independent rudders and thrusters;

   standby and rescue including deployment of fast rescue craft, and recovery of survivors from lifeboats, rafts and the water;

   offshore cargo transfer, anchor handling;

   iceberg towing;

   diving support;

   dynamic positioning;

   MODU disasters, including blow-outs and maritime accidents.

2. All crew members regularly employed on support vessels should have the same level of training in basic safety and survival as MODU crews, including training on specialized life saving appliances not covered by MED II.

3. Deck hands who engage in certain hazardous offshore activities such as anchor handling, cargo transfer and iceberg towing should have specialist training and work under supervision until fully experienced.

4. Drills for seamen are essential for monitoring emergency skills. Changing scenarios are also essential.

5. Training for engineers is fairly satisfactory in terms of quality of content. The major problem in Canada is insufficient candidates for the senior levels.

6. Two possible areas for improvement in the content of engineers' training are: to keep training up to date with state-of-the-art technologies, and to offer specialist training in new technologies, as optional subjects.

7. For electronic technicians, the formal training available is satisfactory. The main requirement is for employers to hire competent persons and ensure they are trained for the specific equipment they will use.

8. Diving supervisors need prior knowledge of divers and diving, but training on the specifics of vessels and their equipment is best acquired on the job.

9. The role of the standby vessel has not been sufficiently defined for the necessary duties to be fully understood. The use of supply or anchor handling vessels in the secondary standby/rescue role means that, to provide an effective service, many more persons must be trained than if dedicated vessels are used.

10. The training of deck hands of vessels during standby/rescue duties off Eastern Canada is inadequate in the use of the specialized equipment, new techniques and handling large numbers of casualties.

11. A pre-requisite for standby/rescue vessel crews should be considerable seafaring experience, preferably on vessels of equivalent size.

12. A course needs to be developed which gives the crew a thorough grounding in standby/rescue duties.

13. On the job practice is essential, particularly where fast rescue boats are employed, so that the crew can operate to the limits of the craft in bad weather. A stable crew membership greatly enhances the effectiveness of this practice, by developing teamwork.

6. AIRCRAFT SUPPORT

Air support for offshore operations off Eastern Canada is exclusively by twin-engined helicopters, fully equipped and crewed for instrument flying. Government control of flying is extremely tight with respect to equipment, personnel and operations.

Local offshore helicopters are equipped to carry hoists, which together with rescue equipment are held ready onshore, but no rescue specialists are employed. In other offshore areas, such as the North Sea, government search and rescue services are more developed than in Eastern Canada. However in the North sea sector several operators themselves maintain quite extensive search and rescue capabilities in multi-platform fields or remote areas. Eastern Canada is not yet at the stage of oil field development where this is feasible. Government/military capabilities are not the subject of this report, but Canadian commercial helicopters could, at least under daylight visual flight rule conditions, mount SAR operations, given the proper training of the crew.

Escape from a helicopter down in the sea (helicopter under water escape training or HUET), in-flight cabin fire fighting and first aid, all need to be considered for flight crew training, and HUET at least for passengers too.

Conclusions on Aircraft Support

General:

1. Regulations for aircrew training are strict and basic flying training for helicopter crews, coupled with operating company requirements for experience are adequate.

2. Canadian SAR services are not adequate for the vast offshore area and have to be supplemented by operating companies' helicopters, which are less well equipped for rescue and do not have specially trained crews.

3. Local offshore helicopters are equipped to carry hoists, which together with other rescue equipment are held ready onshore.

Canadian needs:

1. All round emergency training should be considered for the crew, especially HUET and inflight cabin fire fighting. No facilities yet exist for HUET.

2. Survival and first aid training for crew members would enable them to deal with emergencies, while awaiting assistance.

3. At present no formal training courses in rescue exist, although some companies provide their own capabilities. Consideration needs to be given to the provision of SARTECH training of civilian personnel, if the military SAR capability cannot be developed.

7. GENERAL CONCLUSIONS

In this report conclusions have been drawn on training in various aspects of offshore activity. In addition to the conclusions specific to MODUs, and their marine and aircraft support, there are some factors which affect all offshore training in the Eastern Canadian region. These are set out below:

1. Environmental conditions off Eastern Canada are bad, with rough weather, fog and the possibility of icebergs and pack ice.

2. The area of operation can be far offshore and isolated from centres of population.

3. Training is needed for aspects of safety, rescue and general operation. This needs to take into account the specifics of the harsh and isolated region.

4. Canada has a history of marine training and land based drilling training, with important and reputable establishments. Some of these have developed training for offshore or MODU operations.

5. A representative national (or at least an East Coast) forum, enabling operators, contractors and training establishments to discuss and establish training standards with national and provincial Governments would help ensure that the training met with general acceptance with respect to standards and economy.

6. Good training is expensive - full size equipment and elaborate simulators are needed for some aspects of offshore training. A means for funding further developments needs to be established. At the same time it must be born in mind that expenditure on training can increase to any amount available, and suitable controls need to be established.

7. Government recognition of courses and qualifications, with proper monitoring, helps to ensure high standards and wide acceptability.

8. Regulations or other Government legislation may be needed to achieve some of the necessary results.

9. Regular drills are needed to keep the training fresh in the minds of all personnel.

TASK AND SKILL ANALYSIS OF AGENCIES REGULATING EAST CANADA OFFSHORE DRILLING

Submitted

to

ROYAL COMMISSION ON THE
"OCEAN RANGER" MARINE DISASTER

NATIONAL PETROLEUM AND MARINE CONSULTANTS LIMITED

JUNE, 1984

EXECUTIVE SUMMARY

The primary objectives of the study were to carry out a task and skill analysis of agencies regulating the safety of Eastern Canada offshore drilling. The agencies included in the study are Canada Oil and Gas Lands Administration, Canadian Coast Guard, Newfoundland and Labrador Petroleum Directorate and Nova Scotia Department of Mines and Energy (Petroleum Resource Division).

The analysis addresses both managerial and technical skills in each agency. In the first instance, the required skills are identified, then the existing skills are examined in light of the requirements.

Management skills are addressed from the perspective of Senior Management Group, Middle Management, and Inspection Group. Technical skills are examined from the perspective of particular functional requirements.

The conclusions arising out of the study are mainly centered around the need, within agencies for more experience in and knowledge of the offshore industry which they regulate. The most important recommendations made by the study team are cited here.

That COGLA recognize the importance of offshore petroleum industry knowledge as a prerequisite for decision making at the Senior Management level, that they encourage senior management personnel to augment the existing quota of expertise with input from technically knowledgeable peers and subordinates, and that they encourage senior personnel to increase their own exposure in this area whenever possible, particularly with regard to new petroleum-related technologies.

That COGLA place greater emphasis on industry-related and technical expertise when choosing and training personnel for inspections positions.

That CCG encourage its Senior Management to recognize the difficulties inherent in the transfer of operations from a marine focus to a combined marine and petroleum - development focus, and that they continue to strive for a balance between the requirements of the two sectors by increasing their expertise in the new area and promoting co-operation among the various factions involved.

That NLPD recognize the importance of some form of petroleum industry experience or apprenticeship as a supplement to government or managerial expertise in decision-making at senior levels, and that they continue their efforts to provide this mix within their ranks.

OCCUPATIONAL HEALTH STUDY

CENTRE FOR OFFSHORE AND REMOTE MEDICINE

FACULTY OF MEDICINE

MEMORIAL UNIVERSITY OF NEWFOUNDLAND

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February, 1984

EXECUTIVE SUMMARY

Chapter 1

INTRODUCTION

The MEDICOR team, who prepared this report of their study of health and health care of offshore workers in Eastern Canada, was composed of individuals who collectively could bring to bear a broad range of medical expertise, experience and interest. In dealing with some issues, general medical principles could be applied, but in others, wider approaches had to be taken. In such instances, consultations were undertaken with experts in industry or in government in Canada and in countries where offshore operations had been undertaken for longer periods.

"Offshore Medicine" is an emerging area of specialization, but it has not yet developed a body of rigorously tested scientific information from which principles can be drawn. The available background literature is largely in the form of ad hoc accounts of experience, much of which is unpublished.

The method used by the team in preparing the report was largely consultative. Some data were gathered, but the main emphasis was on collecting information from government agencies, industry, educational institutes and from groups and individuals in Canada and in the United Kingdom, United States of America and Norway. This information was discussed by the team and its relevance to the conditions affecting Canadian East Coast petroleum operations was assessed. The data base includes minutes of these discussions, specially commissioned reports from consultants and resource experts and accounts of meetings and visits.

The report was organized to follow the sequence of events starting with a worker seeking employment. Certain jurisdictional, legal and administrative matters are considered as background at this stage. Before he proceeds offshore the worker is given a pre-employment assessment and undergoes training, including First Aid training. The potential hazards, accidents and illnesses

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The chapter headings used in the Executive Summary correspond with those used in the main report.

The Conclusions and Suggestions outlined in the Executive Summary are of a general nature, for specific detailed information the reader should refer to the main report.

which can arise in the offshore workplace are then discussed with emphasis on the preventive health and safety aspects. The health resources on the rig are reviewed, including personnel, supplies, space, equipment, and medications. It is recognized that in some instances consultation with a shore-based physician will be required, and the need may arise for the physician to visit the offshore installation. The supplies required for such a visit and the need for backup medical coverage are discussed. The significance of communication and transport is outlined. Land-based services may be sought either by utilizing the services of a Medical Emergency Response Team, or by evacuation to and reception at a shore-based medical facility.

The relevance of support services, such as support vessels and standby vessels, and the unique problems of diving, hypothermia and exposure are considered. The worker who has been evacuated for medical reasons may return to the job or require short- or long-term rehabilitation. Throughout the report the relationships between the various agencies responsible for aspects of offshore health are discussed and a method of maintaining and reviewing an overall emergency plan is proposed.

Chapter 2

JURISDICTIONAL, REGULATORY, LEGAL, & ADMINISTRATIVE CONSIDERATIONS

2.2.1 A brief review of regulatory structures in other countries indicates that in Norway the regulatory agency for fixed platforms differs from that for mobile offshore drilling units (MODUs). While health and safety matters in the offshore are dealt with by a number of different departments and directorates, registration of health professionals is straightforward. There is a highly detailed regulatory system but confusion and misunderstanding can still arise in the compliance expected of operators. Norwegian regulations specify the right to inspect installations without notice. This requirement is likely to lead to effective enforcement.

2.2.2 In the United Kingdom, responsibility for health, safety and welfare has been delegated to the industry. Government implements guidelines rather than detailed regulations, and inspection of rigs and installations is arranged at times convenient to the company. There is no requirement to register health professionals working offshore and education, training, and determination of qualifications is the responsibility of the industry. The industry has responded by instituting an active association, United Kingdom Offshore Operators Association (UKOOA), which has developed standards for health and safety. These standards exceed those suggested by government. The strength of the United Kingdom position lies in the use of the 'single window' (Department of

Energy) with prime regulatory responsibilities. The Health and Safety Executive has played a significant role in developing occupational health and safety regulations. The consultative process appears to have resulted in mutual acceptance of guidelines.

2.2.4 In Canada, regulatory requirements exist at Federal and Provincial levels. Enforcement of regulations dealing with health and safety is hindered by the fact that many of the vessels in the offshore operation are foreign registered and standards of health care, training of personnel, equipment, and supplies are based on the regulations of the country of registration. While legislation would be required at both Federal and Provincial government levels to enforce standards, compliance could be effected under the present licensing system, in which the operating company, its contractors and subcontractors would be required to assume full responsibility to meet standards of health and safety.

Licensing of all MODUs to a minimum Canadian standard would vastly improve contingency planning and facilitate health care.

2.3 The emergence of the Canada Oil and Gas Lands Administration (COGLA) as the primary Federal regulatory agency could have the advantage of providing a 'single window', provided that ambiguities and overlapping responsibilities with other Federal agencies were resolved. COGLA has initiated consultations at the provincial level, particularly with departments of health.

In Newfoundland, health and safety matters, in general, fall under the jurisdiction of the Department of Health, the Department of Labour, and the Workers' Compensation Board. The Newfoundland and Labrador Petroleum Directorate (NLPD) has responsibility for offshore health and safety and should operate in consultation with these other agencies.

In Nova Scotia, control and regulation is vested in the Federal Government, while the Workers' Compensation Board, on behalf of Government, conducts health and safety inspections and accident prevention training for the offshore and for other industries.

2.4 Although registration and licensing of health professionals is an accepted practice, this form of enforcement is hindered by the present limited jurisdiction offshore. Physicians and nurses are licensed at the provincial level, but non-Registered Nurse (RN) medics (TQ6B) are not recognized.

2.5 Physicians and nurses working offshore are not covered by the malpractice insurance policies of their respective professional organizations. They have had to obtain malpractice coverage through private plans because, in attending a patient on a foreign registered installation, they are at risk of suit for malpractice under the laws of the flag country.

2.6 In the Canadian oil industry, the executive management roles of physicians have been limited in comparison to their counterparts in Norway and the U.K. On the rig the medic, who is administratively responsible to the manager, may be clinically responsible to doctors from different companies. Clear guidelines establishing the roles of the physician within the company, and the relationships between medics and physicians are required with the operator's medical director having final responsibility for all health care offshore.

2.7 There has been relatively little communication between physicians in government and industry, but as more expertise in offshore medicine is developed and identified, this deficiency is being corrected.

CONCLUSIONS

(A) At present, offshore health and safety jurisdictional and legal matters are more complex in Canada than in the U.S.A., U.K., or Norway.

(B) To achieve uniformity of health care and unambiguous regulatory structures, Federal and Provincial government agencies must develop coordinated approaches.

(C) By enacting legislation, Canadian and provincial laws could apply to the offshore, and adequate standards of health and safety could be ensured.

(D) Physicians in industry should be given greater responsibility in health and safety.

(E) Standards of practice and training of health professionals cannot be enforced because of the present licensing arrangements and the lack of recognition of qualifications of the non-RN medic (TQ6B). The usual Canadian malpractice insurance does not cover practice offshore.

(F) The executive management role of physicians in the industry has not been recognized. Offshore practice requires clearly established responsibilities for the medic and physician.

(G) Government departments and agencies should have active advisory groups so that consulting expertise can be built up.

(H) To facilitate contingency planning and health care, MODUs operating on the Canadian East Coast should be licensed to a common minimum Canadian standard.

SUGGESTIONS

(1) To reduce the complexity and overlap from multiple regulatory agencies the concept of the 'single window' should be stressed. COGLA at the Federal level and NLPD at the Provincial level should consult with other involved agencies to reduce ambiguities and develop coordinated approaches.

(2) Until the necessary legislation is enacted, the licensing process can be used to establish compliance with health and safety standards by requiring the licensed operator to comply with the regulations for all workers.

(3) Licensing and certification for offshore health personnel should be rationalized. A method should be devised of granting recognition to the qualifications of non-RN medics (TQ6B) and the possibility should be explored of extending professional organizations' malpractice insurance to the offshore.

(4) The operator's medical director should be responsible for the health and safety of all workers on the MODU, including employees of all contractors and subcontractors.

(5) Clear guidelines should be developed to cover the role of the medic and physician in dealing with medical problems on installations.

(6) Greater expertise in offshore medicine should be developed within government to provide a source of advice and consultation.

(7) All MODUs should be licensed to a common minimum Canadian standard.

Chapter 3

PRE-EMPLOYMENT MEDICAL ASSESSMENT

3.1 Because of the nature of the workplace, every employee in the offshore will have to be fit to perform satisfactorily, both on the job and in an emergency, without risk to himself or to his colleagues.

3.2 Compared to other countries, pre-employment medical examinations in Canada are not standardized. The examining physician should have expertise in offshore medicine. The establishment of common guidelines would allow standards to be applied across the industry, although it is accepted that clinical judgement must

operate. The medical information is to be considered as confidential between the physician and the worker unless the worker consents to its release.

A list of contraindications for employment offshore is presented, based on standards published by the Medical Advisory Committee of UKOOA. Special requirements and assessments must be undertaken for workers in certain areas such as caterers, divers, or helicopter pilots.

It is suggested that, logically, medical examinations for fitness should be conducted prior to offshore training programs, since some parts of these programs are significantly stressful.

CONCLUSIONS

(A) Pre-employment medical standards should be applied across the industry.

(B) The regulatory agencies should be responsible for determining minimal acceptable pre-employment criteria for offshore workers.

(C) Special examinations and assessments are required for workers in certain categories.

SUGGESTIONS

(1) A standard pre-employment assessment should be conducted on all offshore personnel by a physician with training in this type of assessment.

(2) Contraindications to employment should be clearly set out.

Chapter 4

GENERAL REVIEW OF THE OFFSHORE LABOUR FORCE AND WORK ENVIRONMENT

4.2 A comparison of workers in Newfoundland and Labrador petroleum operations, with the total Provincial male labour force shows that the offshore employee is more likely to be single or separated, and to have post secondary education.

The total complement of a drill unit is 80-90 and that of a standby/supply vessel is approximately 17.

4.3 The recognized requirements for the operational environment are discussed under the following headings:

4.3.1 Ventilation and Heating - to include humidification, prevention of circulation of dust and odours.

4.3.2 Sleeping Quarters - the tendency to assign one or two berth cabins; the need for regular changes of bed linen; toilet and shower facilities.

4.3.4 Sick bay - is discussed in Chapter 7.

4.3.5 Corridors - well illuminated, with clear passage and smoke detectors.

4.3.6 Laundry Facilities - sufficient for personal clothing and bed linen for the full complement.

4.3.3 Recreational Areas - multipurpose areas for reading, talking, studying, and which can be used as a casualty station in an emergency.

4.3.7 Catering and Eating Quarters - provision of good food, prepared hygienically, and eaten in pleasing quarters. Nutritional needs and personal choices to be recognized. Periodic monitoring and inspection of supplies and handling.

4.3.8 Potable Water - adequacy of supply; regular monitoring of pH and testing for contamination; protection from extremes of temperature.

4.3.9 Waste Disposal - cleaning and inspection of bulk containers.

4.3.10 Protective Clothing - need for adequate design, which will not hamper the employee at work, but will be wind- a water-resistant.

4.4 The following hazards from the physical environment are discussed:

4.4.1 Thermal Factors - greatest risk is exposure to cold, which may reduce efficiency, contribute to accidents, and lead to hypothermia (discussed in subsequent Chapter 7).

4.4.2 Motion Sickness - is discussed in Chapter 7.

4.4.3 Noise, Vibration - may lead to industrial deafness or produce the effects of nuisance noise. Noise may be a safety hazard when it prevents audible warning being given of danger. Recommended noise limits are quoted, and the need is stressed for employees to be informed of the risks of exposure to excessive noise.

4.4.4 Illumination - standards for illumination should be maintained for safety as well as for operating conditions.

4.4.5 Dust - industrial dust may be a problem for employees engaged in activities such as sandblasting.

4.4.6 Radiation - use of radioactive instruments is regulated and inspected by Atomic Energy Control Regulations of Canada.

4.5 In addition, gases and other substances can be toxic:

4.5.1 Hydrogen Sulphide (H_2S) - employees should be trained in the procedures to be adopted in the event of an escape of this potentially lethal gas.

4.5.2 Methane (Natural Gas) - a fire hazard.

4.5.3 Carbon Monoxide (Fumes) - at high concentrations can produce coma, but lower concentrations may impair functioning to reduce efficiency and cause accidents.

4.5.4 Drilling Muds - dermatitis and eye irritation may arise.

4.5.5 Hydrocarbons - particularly the long-term carcinogenic effects of exposure to crude petroleum.

4.6 Given the nature of the environment and the pressures on the workers, it has been suggested that high rates of psychiatric disorders might be expected among offshore workers. However, evidence that this is so is lacking.

Sources of Stress - from interviews with offshore workers, concerns for family, drug and alcohol abuse, travel by helicopter, noise, limitation of personal space, sleep problems, anxiety about job security were identified. A number of offsetting advantages were noted in subsection 4.6.2.

Concerns about Family. It has been observed that the intermittent husband need not be a major hazard to family unity.

Psychiatric Disorders. Alcoholism, sleep disturbances, anxiety, and depression, as well as major disorders have been reported.

CONCLUSIONS

(A) Attention must be focussed on a wide range of factors in the offshore working environment, especially in matters such as eating facilities, sleeping quarters, and facilities for personal hygiene.

(B) Recreation areas are required and may be used as casualty centers in the event of an emergency.

(C) Workers must be educated on matters of health hazards and emergency procedures.

(D) Reliable data is required on the adverse effects of a number of factors associated with the offshore environment.

SUGGESTIONS

(1) Expert medical input is required in determining the services and lay-out of facilities on an installation.

(2) Regulations are required to determine standards of job safety and the adequacy of living conditions and a monitoring system established to ensure adherence.

(3) Research on a number of problems associated with adaptation to the offshore workplace should be instituted.

Chapter 5

THE INCIDENCE OF ILLNESSES IN THE CANADIAN EAST COAST PETROLEUM OPERATIONS

Because of the nature of the work force and screening by pre-employment assessment, the number of cases of illness is likely to be low.

5.2 It is expected that infections will arise. Dental disorders give rise to problems in the offshore.

5.3 Analysis of a rig medic's log showed that illnesses were more frequent than accidents, but were less severe. The majority of illnesses were mild upper respiratory tract infections, headaches, and minor skin disorders.

CONCLUSION

(A) The types of illness encountered on the Canadian East Coast were similar to those reported elsewhere.

SUGGESTION

(1) A more detailed profile of the health of offshore workers is required and a properly designed system of data collection should be instituted.

Chapter 6

ACCIDENT DATA COLLECTION

Part I discusses the limitations of collecting data on accidents. There are different criteria used in defining a minor accident and reporting of incidents is unreliable. Unreliability in accident data can occur when a 'safety-bonus' system operates.

6.3 While most accidents are neither serious nor fatal, it is difficult to determine cause. The relationship of accidents is discussed to type of facility, the phases of development, specific operations, time relationships, weather conditions, and work environment.

CONCLUSION

Reliable accident statistics are difficult to collect, but they are required to provide a basis for safety education and accident prevention programs.

SUGGESTION

Accepting the limitations of the methods, accident statistics should be collected to determine incidence and determine cause.

6.6 Part II presents an analysis of accident rates on drilling units and standby vessels in the Newfoundland and Labrador offshore and compares the figures with those reported from operations in other parts of the world. On drill units minor accidents were twelve times more frequent than major accidents. Hand and wrist were most commonly injured as a result of "being struck". Major accidents affected roustabouts, roughnecks, drillers, and seamen. On standby/supply vessels, seamen and caterers had the most accidents. The most commonly reported nature of the accident was contusion. These findings agree with other reports.

SUGGESTION

Using more refined methods of analysis and inference, further data should be collected, as their analysis can contribute to an understanding of causes which can be applied in accident prevention programs.

Chapter 7

HEALTH CARE RESOURCES OFFSHORE

A review is presented of sick bay facilities, equipment and supplies, and stretchers. Survival problems and medical supplies in life boats and life rafts are discussed.

7.2 The size and services of the sick bay can be determined using U.K. standards. It should be located so that there is access to the work area and the landing area, with an adjacent area to be used for triage. It should be provided with sound insulation, storage, toilet, ventilation, and temperature control with secure medicine cupboards. Communication should be available to other parts of the installation and to shore bases. An ECG and defibrillator may be

included if the medic is appropriately trained. The provision of X-ray machines is controversial; while they are very useful in many circumstances, they do have safety hazards and the interpretation of radiographs is not a simple matter.

7.3 Although individual medics and physicians will have personal preferences, the medical equipment and supplies for the sick bay on the MODU should be standardized to aid contingency planning. Regulatory agencies should assume the responsibility for framing minimum standards for medical equipment and supplies aboard any unit licensed to operate. In addition to medical supplies there should be adequate stocks of sheets, towels, etc.

7.4 The characteristics of available stretchers are discussed. First Aid training should include instruction on the use and limitations of the stretchers available on the unit (See section 7.5).

7.6 The major problems of survival in life boats are hypothermia, thirst, motion sickness, exhaustion, and hunger. Morale has a significant effect. Hazards must be recognized in abandoning an installation. Improved designs of survival suits are required.

The current Canadian Coast Guard requirements for medical supplies and equipment for life boats and life rafts are reviewed. The most obvious lack is a motion sickness prophylaxis.

7.7 Personnel should be trained in survival techniques and a member of the Advanced First Aid team should be designated for each life boat.

CONCLUSIONS

(A) Medical input is required in determining the design, layout, and equipment of health facilities on installations and vessels.

(B) Minimum standards for equipment should be devised and related to complement.

(C) Current scales of provisions on life boats appear to be satisfactory, but suggestions are offered for additions to the medical lists to be carried on life boats and life rafts.

(D) The current generation of survival suits has design weaknesses.

SUGGESTIONS

(1) Regulatory agencies should specify minimum standards for medical equipment and supplies for use offshore.

(2) For an offshore installation, ten rescue stretchers and one Neil Robertson or Paraguard, and one Orthopaedic Scoop should be available.

(3) Personnel should receive survival training. All workers should have First Aid training and an Advanced First Aid worker should be assigned to each life boat.

(4) Additions should be made to the medical kit required under present Canadian Coast Guard regulations and dosages of medications should be expressed in metric units.

(5) Further research and development is needed to improve the design of survival suits and achieve the best compromise between requirements for manoeuvrability, thermal protection, buoyancy, and flotation characteristics.

Chapter 8

REVIEW OF OFFSHORE HEALTH PERSONNEL DUTIES, QUALIFICATIONS, AND CONTINUING MEDICAL EDUCATION

8.2 The rig medic may work in lieu of a physician or as an extension of the shore based company doctor. The duties range from conducting a routine sick parade to handling multiple casualties. Under certain circumstances, a patient may have to be cared for over a long period. In emergencies, the rig medic should be supported by a competent team trained in Advanced First Aid.

A wide range of skills is required of the medic ranging from carrying out public health inspections to doing minor surgical procedures. While the medic may be given other duties, these should not conflict with medical duties. Because of the organizational structure within the company and its contractors conflicts of responsibility may arise.

In Canada rig medics may be qualified nurses, ex-military medics, or emergency medical technicians. The emergency medical technician training is the least appropriate for the role of the rig medic. The TQ6B ex-military medic, particularly with sea going experience, is qualified for rig medic duties but at present has no legal status as a health professional.

8.3 All offshore health personnel including physicians and medics will require some training before taking up duties. Modular courses of training would accommodate individual backgrounds and experience.

8.4 Continuing education courses should be conducted at regular intervals to ensure that infrequently used skills are updated.

CONCLUSIONS

(A) Standards of health practice should be maintained by ensuring appropriate basic training and conducting courses in continuing education.

(B) Education and training should be linked to the duties expected.

(C) Basic First Aid training should be given to all workers and a team of Advanced First Aid workers should be available to assist the rig medic in emergencies.

SUGGESTIONS

(1) Basic First Aid training is advocated for all workers, the standards should be set by the regulatory agencies.

(2) A team of Advanced First Aid workers should be formed to assist the rig medic, who should be responsible for their training.

(3) A method of gaining recognition for the TQ6B ex-military medic should be established.

(4) Training and continuing education courses should be conducted by appropriate educational institutions.

Chapter 9

FIRST AID TRAINING FOR OFFSHORE WORKERS

The previous suggestions of Basic First Aid training for all workers and the formation of an Advanced First Aid team are elaborated by a discussion of the content of the courses.

9.2 Basic First Aid training is advocated for all offshore workers and the present Marine Emergency Duties course should be modified to include topics of relevance to the offshore. As the conventional course may not be suitable, regulatory agencies should assume responsibility for approving course content, monitoring the examination procedures and certifying the adequacy of the instruction to be offered. An outline of a suitable course of training is presented in an appendix.

9.3 A member of the Advanced First Aid team could serve as an escort for a patient being evacuated, and the medic should run First Aid drills and provide instruction to the team on topics such as transportation of the patient, resuscitation and the use of the sick bay equipment. A record of drills should be maintained.

CONCLUSIONS

(A) First Aid courses for all workers should include instruction in safety-oriented First Aid, cardiopulmonary resuscitation, hypothermia, near-drowning, and hydrogen sulphide poisoning.

(B) The basic course should be supplemented by refresher courses.

(C) The Advanced First Aid team should consist of sufficient personnel to assist the medic and act as escorts when a patient is being transported.

SUGGESTIONS

(1) The regulatory agency should certify First Aid courses specifically developed for offshore workers to include topics appropriate to the offshore setting.

(2) Refresher courses should be held on a regular basis.

(3) The rig medic should be responsible for organizing the Advanced First Aid team and should maintain its training by on-the-job training and regular drills. An adequate record of drills should be maintained.

Chapter 10

STANDBY VESSELS

10.1 In the Canadian East Coast operation supply vessels also serve as standby vessels.

10.2 The functions of these vessels are set out in regulations of the NLPD. Although there is controversy about their dual role, the implications are discussed here in the context of health and safety.

10.3 The Hollobone, Hibbert and Associates Limited report on the "Use and Effectiveness of Standby Vessels (Rescue Ships) in offshore operations concluded that on balance, the advantages of standby vessels outweigh their disadvantages. However, this balance should be reassessed in the context of the East Coast operations and expert study on their role in rescue is required.

10.4 The distances on the Canadian East Coast are greater than in the North Sea and survival time is limited because of the low water temperature. This suggests a need for an immediately available standby vessel.

10.5 The rescue roles of standby/supply vessels, hospital ships and helicopters are considered. Several issues are outlined which require further consideration before the uncertainty as to the purpose of the standby/supply vessels on the East Coast is resolved. Hospital ships are not considered feasible at the current level of offshore activity. Under certain conditions, helicopter transfer or evacuation of casualties may not be possible.

10.6 The medical role of standby vessels is considered in the light of the types of casualties to be expected - such as trauma, burns, near-drowning, or hypothermia. Their record in rescue is not convincing.

10.7 A crew member should have sufficient training (at least to an Advanced First Aid level) to serve as medical attendant on the standby vessel. There is a lack of consensus about the medical supplies to be carried on a standby vessel, but two major determinants can be identified: the nature and numbers of probable casualties and the training of the medical attendant.

CONCLUSIONS

(A) Supply vessels also function as standby vessels; they have a role which has some medical aspects.

(B) Their record in successful rescue is not convincing.

(C) In addition to having First Aid training for the crew, a medical attendant should be designated.

SUGGESTIONS

(1) Crews of standby vessels should be trained in First Aid and one member should have sufficient further training to act as a medical attendant.

(2) A standard list of medical supplies and facilities for standby vessels should be devised appropriate to their role and the training of their medical attendants.

(3) Further investigations should be undertaken of the methods of rescue which can be used in standby vessels.

(4) The question of their dual purpose and the role of standby vessels in rescue should be studied by a group of experts.

Chapter 11

COMMUNICATIONS AND TRANSPORTATION

11.1 Requirements for communication are set out under COGLA regulations covering communication within the installation, to and from other vessels, and to and from onshore bases. The sick bay should be capable of communicating with other parts of the installation and with shore bases.

HF and VHF systems in current use have limitations. Newer systems have been developed using new techniques. Telemedicine can permit communication of medical data visually.

11.2 Distances and transport times on the Canadian East Coast are listed. The available services in Newfoundland and Labrador are reviewed.

Although there are weather restrictions, transportation by helicopter is preferable to transportation by sea. Evacuating a patient by air requires an escort and special planning is required to accommodate support equipment. Disadvantages are the noise and vibration, cramped conditions, and the effects of high altitude on a patient.

CONCLUSIONS

(A) Because of the crucial importance of communications in a medical emergency, reliable systems must be devised and tested.

(B) Satellite technology may provide cost-effective alternatives.

(C) Newer communications technology will demand new skills from operators.

(D) While transport by air is preferred to transport by sea, special planning can be required for transport of patients.

(E) The patient should be stabilized before being transported and an escort should be available.

(F) Ambulance services are crucial and play a fundamental role in medical evacuation.

SUGGESTIONS

(1) Industry and the agencies should keep abreast of the new technology in communications.

(2) Training of operators is required to ensure optimal use of communications systems.

(3) Health personnel should become aware of the advantages and drawbacks of various forms of transportation especially in evacuating patients with life support systems.

(4) Ambulance services should be upgraded to provide facilities for advanced life support. Attendants should be trained to acceptable standards and one-man ambulances should be avoided.

(5) For emergency planning an inventory should be taken of vehicles suitable for ambulatory services available from other resources.

Chapter 12

DIVING

The special problems of health and safety in diving are discussed.

12.2 The Canadian Standards Association (CSA) and COGLA have recently produced a standard and regulations, respectively, which reflect modern diving practice. However, in a few areas there are inconsistencies between the standard and the regulations. The COGLA draft regulations do not address surface decompression diving and the training of life support technicians is addressed only briefly.

Company contingency plans should cover the evacuation of divers in the event of abandonment of the MODU and indicate that rescue operations can be undertaken from a diving bell trapped on the sea bottom. The procedures manual should specify the responsibilities and duties of all personnel and set forth the disciplinary policy of the company.

12.3 Diving regulations may be enforced by government inspection or by contract, whereby the operating company is required to assume responsibility for the conformity of its diving subcontractors. Both methods suffer from the drawback of the shortage of suitably qualified personnel to carry out enforcement. When being drafted, regulations should be set out so that they can be realistically applied in practice.

12.4 Communications are required for diving operations and for safety purposes and are vital in an emergency. When treatment is being conducted in a compression chamber, it is desirable that the person making the decisions be outside the chamber with clear communication links to the person inside conducting the

procedures. The diving station should also have direct reliable communications to shore preferably using a satellite link.

12.5 Diving accidents have occurred when diving was undertaken from dynamically positioned vessels. This mode of diving should be the subject of ongoing scrutiny. Research and development is required to extend the diver's survival time if the surface gas supply fails, particularly in deep diving.

12.6 Treating a sick or injured diver can be a complex operation. Days may be required to bring a diver in saturation to the surface and hours to compress an attendant to enter the chamber to render aid.

All divers should be trained to a high standard of First Aid, including training in the First Aid of diving emergencies. Neither the rig medic nor the diving superintendent can attend the patient in the chamber so diving teams should include divers who have been trained as diver/medical technicians to render immediate medical care.

In an offshore diving accident the priorities are to recover the diver into the onsite recompression chamber then to initiate treatment using immediately available resources and personnel, with consultation of a medical expert onshore. In some instances, the diving specialist physician may travel offshore, possibly with members of the Medical Emergency Response Team, taking necessary monitoring supplies and other equipment.

12.7 If transfer of the diver-patient to a shore-based facility is contemplated, the patient should first be stabilized in the offshore chamber and a rescue system involving a 'fly-away' chamber could be utilized.

Evacuating an installation because of weather or danger of iceberg collision presents problems for divers in saturation. The methods available include transfer to a support vessel, using a 'fly-away' hyperbaric chamber or the hyperbaric life boat. Technical problems of using these systems individually or in combination have to be solved.

12.8 A study is being undertaken on the provision of an onshore medical hyperbaric facility at the Health Sciences Centre in St. John's. Some specifications have been developed, but other features of size and design have still to be established.

In Halifax, a hyperbaric facility is being installed at the Victoria General Hospital, and plans for a new diving school will include a saturation diving facility which could be used for medical purposes in an emergency.

12.9 Special training in hyperbaric medicine is advocated for diver medical technicians, life support technicians, diving supervisors,

medics and physicians. Because diver medical technicians are not recognized in Canada, they cannot perform medical procedures on patients during their training. Training models and anaesthetized animals could be used and recognition could be granted if the training were given under the Canadian Medical Association's (CMA) Emergency Medical Attendant program.

Diving supervisors should be familiar with the concepts of diving medicine and physiology in addition to their knowledge of operational diving procedures.

Physicians should be specially trained in the conduct of medical examinations for fitness to dive and some should be trained as specialists in diving medicine. Such courses are most readily available outside Canada. Refresher courses could be held for specialists already trained.

12.10 Training of divers can be achieved at schools for commercial diving, but diving in the offshore oil operations requires further experience. The current shortage of experienced divers to act as supervisors will be overcome as more Canadians become skilled and knowledgeable.

Training requirements can be met in the planned diver training school in Nova Scotia. High standards of training can be maintained by adherence to the COGLA diving regulations.

12.11 Research needs are identified in diving medicine and physiology in the development of improved "bail-out" gas supply systems for deep diving, the physiology and pathophysiology of decompression sickness, thermal protection and oxygen toxicity.

CONCLUSIONS

(A) Current diving regulations in Canada compare favourably with those of other countries, but some inconsistencies between CSA standards and COGLA regulations are noted. Training of life support technicians is only briefly covered by the COGLA Diving Regulations.

(B) Procedures which involve diving hazards are diving from a dynamically positioned vessel, deep diving without a closed bell and SCUBA. These are covered by the regulations.

(C) Contingency plans prepared by diving companies should be scrutinized by regulatory agencies.

(D) Communication techniques are essential for diving operations and are crucial in emergency situations.

(E) The diving team should be capable of rendering immediate First Aid and emergency medical technicians should be available to undertake treatment in compression chambers.

(F) Generally only conservative treatment should be undertaken offshore for trauma and intercurrent illness. However, complex procedures may have to be carried out by specialist physicians.

(G) Transfer under pressure of divers presents difficulties which are not fully resolved; in particular modes of evacuation of a threatened diving system remain controversial.

(H) Planning is being undertaken for a hyperbaric facility in St. John's. Adequate facilities are already at an advanced planning stage in Halifax.

(I) Training in diving medicine and safety should be provided for a wide range of personnel.

(J) Research programs are required in a number of areas in diving medicine.

SUGGESTIONS

(1) The training needs of life support technicians should be addressed under the Canada Oil and Gas Lands Administration Diving Regulations.

(2) Diving companies and regulatory agencies should be aware of advances in communications for use in diving operations.

(3) Training needs for diving personnel should be met; training programs and some status should be sought for diver/emergency medical technicians. Refresher courses should also be organized.

(4) Special training is necessary for physicians who undertake examination for fitness to dive and for those who will act or specialize in diving medicine.

(5) An onshore hyperbaric facility should be provided in St. John's.

(6) Research in a number of areas of diving medicine should be encouraged.

Chapter 13

ONSHORE MEDICAL RESOURCES IN NEWFOUNDLAND AND LABRADOR AND NOVA SCOTIA

13.1 The land-based medical resources include the company physicians, the Medical Emergency Response Team and the primary, secondary, and tertiary medical facilities in Newfoundland and Labrador.

13.2 Physicians provide services under contract to companies either individually or in groups. The company physician decides on the method of handling an emergency and the type of assistance required.

A Medical Emergency Response Team is currently available on an ad hoc basis from the General Hospital at St. John's. Arrangements are being made to institute this on a formal basis.

A protocol for activation of this team has been developed.

13.3 The resources of the hospitals in St. John's are listed with respect to their general and specialist facilities, their disaster plans, proximity to helicopter landing sites. Ambulance services, discussed previously in Chapter 11 could be improved by the use of a modular vehicle with life support equipment and by ensuring an adequate level of training for all ambulance drivers.

13.4 The hyperbaric facility located at the Marine Sciences Research Laboratory at Logy Bay is inadequate for medical purposes.

13.6 The pattern of medical evacuation from the offshore MODUs is described.

13.7 This pattern is extended to view the province by region and a listing is supplied of the hospital services and facilities in each of these regions.

13.8 The available medical facilities and services in Halifax are described. A formally organized Medical Emergency Response Team has not yet been established.

As in St. John's, physicians provide services under contract to companies either individually or in groups.

The resources of the hospitals in Halifax are listed with respect to their general facilities and their disaster plans.

13.9 The availability of various specialty resources in Halifax hospitals are outlined. Hyperbaric facilities are identified.

13.10 Ambulance service in the Halifax/Dartmouth area is provided by private enterprise and through the Victoria General Hospital.

With the development of offshore operations, a formalized procedure for air evacuation will have to be established.

The helicopter landing sites in the Halifax area are identified.

13.11 The hospital and medical services in Antigonish and Sydney are reviewed.

13.12 Public health physicians should be involved at various levels of offshore operations. Some public health physicians should be trained in offshore medicine and health.

CONCLUSIONS

(A) The basic data for emergency evacuation from offshore to onshore facilities has been collected.

(B) Individual hospitals have disaster plans.

(C) The Medical Emergency Response Team has been set up on an ad hoc basis in St. John's.

(D) The provision of modular units and improved training of ambulance drivers are recognized as important advances.

(E) A formally organized Medical Emergency Response Team has not been established in Nova Scotia.

(F) A formalized procedure for air evacuation from the Venture field has not yet been developed.

SUGGESTIONS

(1) All communities should have an integrated disaster plan.

(2) The St. John's Inter-Hospital Disaster Committee should complete a coordinated Hospital Disaster Plan.

These are Newf. only

(3) The General Hospital, Health Sciences Centre, should be designated as the Medical Control Base for pre-hospital emergency medical response to the Newfoundland and Labrador offshore.

(4) There should be a formal categorization of the emergency capabilities of the three St. John's hospitals, specifying the number and type of patients each should receive in a disaster situation.

(5) A similar categorization should be made for the strategically located medical facilities in Goose Bay, St. Anthony, Gander, Corner Brook, Stephenville, and Burin.

(6) The development should be considered of an integrated medical communications network connecting the designated centres and accessible to all agencies involved in disaster management.

(7) Formal designation of a medical emergency response team to respond to offshore and onshore emergencies should be considered. A formal procedure for air evacuations should be established for the Venture field.

Chapter 14

MEDICAL EMERGENCY CONTINGENCY PLANNING

14.1 When an emergency occurs, there must be a contingency plan in place to ensure that the patient is provided with the best care at every stage of management, from immediate First Aid to eventual treatment in a land-based facility such as an intensive care unit.

14.2 COGLA and NLPD require all companies to have a contingency plan.

14.3 The contingency plan may cover emergencies which can be dealt with by the company alone or by using resources external to the company. These plans generally do not delineate clearly the lines of responsibility and relationships between rig medics, physicians and administrators.

14.4 The regulations by COGLA and NLPD covering contingency plans are reviewed briefly. NLPD assumes the coordinating role in an emergency, but clarification of the relationships with other agencies is needed. COGLA delegates the responsibility for emergency health care to the provincial agencies.

14.5 The Federal agencies involved are the Canadian Coast Guard and the Department of National Defence, Search and Rescue organization. At the Provincial level, the agencies are the Emergency Measures organization, the Departments of Health, Labour and Manpower, and Workers' Compensation Board.

14.6 COGLA regulations indicate that the contingency plan submitted by a company must mesh with the plans of contractors and subcontractors and should outline the responsibilities of key personnel onshore and offshore.

14.7 Contingency plans submitted by three oil companies are reviewed and some deficiencies are noted. Active involvement of health and

safety professionals from industry and other agencies will help to ensure the development of contingency plans that are reasonable, practical and acceptable to industry, as well as to the regulatory agencies.

14.8 As a result of meetings between representatives of the various agencies involved in offshore emergency health services, consensus was reached about the general procedures to be followed. Some uncertainties exist about the roles of certain agencies. To reduce these uncertainties and to provide continuity, a standing liaison committee is proposed with a range of functions from reviewing collectively the emergency response capability of each organization to facilitating disaster exercises.

CONCLUSIONS

(A) The regulatory agencies have developed standards for the contingency plans submitted by companies, which require that the roles of key personnel be defined.

(B) Health and safety professionals from industry and other agencies should be involved in the development of medical emergency contingency plans.

(C) The operator can cope with the majority of problems using his own resources, but on occasion will require assistance from other sources.

(D) Some advances have occurred in the coordination of various agencies, but there is still uncertainty and a potential for confusion and misinterpretation.

SUGGESTIONS

(1) The operating company's medical director should be responsible for medical emergency services for all rig workers. The responsibility may be delegated, but not to more than one physician (with back-up coverage). The ultimate responsibility must rest with the medical director.

(2) A standing liaison committee on emergency contingency services, composed of representatives of the major agencies would facilitate the development of a plan acceptable to all, with clarity of responsibility being identified.

DRAFT

ASSESSMENT OF THE MEANS FOR ESCAPE AND SURVIVAL IN OFFSHORE EXPLORATION DRILLING OPERATIONS

Prepared for the Royal Commission on the Ocean Ranger Marine Disaster by Hollobone Hibbert and Associates Limited.

June 1984

2. EXECUTIVE SUMMARY AND CONCLUSIONS

2.1 SUMMARY

The basis on which this report examines the means of abandonment and survival from MODUs, supply ships and helicopters off the East Coast of Canada is as follows.

2.1.1 Situations Leading to Abandonment

First, the situations which could give rise to a need to abandon such units are assessed in Section 3. In semi-submersible drilling rigs, these are concluded to be:

- structural failure resulting from collision or blow-out or from design or other intrinsic fault

- stability loss resulting from incorrect ballasting or loading of consumables

- fire, either of a normal ship type or resulting from a blow-out

- unignited gas following a blow-out.

In jack-up drilling rigs, the same situations prevail except that stability failure while jacked up could also result from penetration of a leg through the sea bed surface, usually termed a punch through.

Drill ships are subject to similar causes of abandonment as semi-submersibles though the manner in which they are manifest is often different and they are manned by seamen who are more likely to survive a maritime emergency situation than are landsmen.

Supply vessels have the normal problems of ships but, because much of their cargo is transferred at sea, particular stability problems are introduced. Furthermore the need for them to operate very close to other units, often for prolonged periods, introduces extra likelihood of collision. Off Eastern Canada a further threat to stability is the possibility of heavy icing of the exposed areas, and the possibility of pooping.

Helicopters either crash, that is to say enter the sea in a completely uncontrolled manner, or ditch, when they enter it with some control. In the former case, the chances of survival are slim indeed. In the latter, crews and passengers may well survive the actual ditching and rely then upon successful abandonment and their subsequent ability to survive.

2.1.2 Factors Affecting Abandonment

From the assessment of the situations which may lead to abandonment can be devised an indication of the likely types of conditions with which successful means of abandonment must contend. With these in mind, the factors which affect abandonment are examined in Section 4. These are divided into four groups, namely

- Environmental
- Physiological
- Mechanical
- Human

Each of these is examined in relation to its effect on abandoning MODUs, supply ships and helicopters off the East Coast of Canada.

The environmental conditions off Eastern Canada are divided into five blocks in which they are similar. These blocks represent geographical and seasonally

linked areas. In general terms, throughout the whole area, examination of historical data indicates typical severe storm conditions varying area by area broadly between the following limits:

- Maximum Wind speed 50 to 70 knots
- Maximum Wave height 6 to 17 metres
- Minimum Air temperature -20° to +11°C
- Minimum Sea temperature - 1.8° + 5°C
- Risk of cloud ceiling under 300ft or visibility less than ½ mile between 15% and 45%

Some icing can be expected in the course of the year in all areas.

Burning oil or gas, heat from flares and unignited gas from blow-outs can all introduce particular hazards to abandonment.

The main physiological factors affecting successful abandonment concern respiration, bodily injury and damage to the heart. The factors which could cause each of these are examined in relation to abandonment.

Mechanical factors affecting the success of abandonment systems are next examined. It is concluded that all MODUs may still provide sufficient security to justify an expectation of successful abandonment up to deck angles of 40° with the horizontal.

Based on current designs, it is concluded that abandonment should be possible from the following heights which represent the height above sea level of relevant decks in the vessels concerned:

- Supply ships	5 metres
- Drill ships	7 metres
- Jack-up MODUs	3 metres (in transit)
	20 metres (on site)
- Semi-submersibles	35 metres (in transit)
	15 metres (drilling)

In helicopters the exit doors may be as much as one metre above or below the surface.

Any power needed by abandonment systems must be available without dependence on the parent unit.

Abandonment systems must be capable of ensuring safe transit of survivors from the point of entry into them to a position clear of the parent unit. Several forms of obstruction can prevent this, ranging from parts of the parent structure, either in way of direct entry to the water or through abandonment craft being swept on to them, to incorrectly working equipment such as release gear for survival craft. Precedent suggests that existing systems are particularly prone to various forms of obstruction.

So far as provision for abandonment by all those onboard units is concerned, it is concluded that, when assessing the optimum number and distribution of abandonment systems it should be assumed that:

- In semi-submersibles and jack-up MODUs, two adjacent sides could be unavailable as a site for abandonment.

- In drill ships either one side or the complete forward, after or midships section cannot be used for abandonment.

- In supply ships and helicopters one side is unavailable for abandonment.

In addition, arrangements for abandoning MODUs should cater for all those onboard the unit including 10% as stretcher cases.

The total time available to abandon vessels, including mustering, preparing equipment and abandonment by total unit complements in likely emergency conditions is assessed to be:

- MODUs : twenty minutes

- Supply ships : thirty seconds providing preparatory precautions are taken early where capsize is deemed a particular hazard. For other causes of abandonment, twenty minutes.

- Helicopters : three minutes.

The simplicity and robust nature of abandonment systems is concluded to play an important part in the effectiveness of abandonment systems, as is the training which users have received about their operation. This training should be both theoretical and 'drill based'.

The availability of means of communication between relevant people during abandonment is deemed to play an important role. In particular they should link the following:

- the parent unit control room
- each abandonment point
- each abandonment craft (if applicable)
- each receiving unit (if applicable).

2.1.3 Criteria for Abandonment

In Section 5, the criteria for abandonment systems are summarised to provide a simple yardstick against which any system can be measured.

2.1.4 Factors Affecting Survival

In Section 6, the factors affecting survival are assessed in the same manner as were those affecting abandonment in Section 4. The main groups of factors are:

- Physiological
- Environmental
- Human
- Rescue factors

Survival in the sea off Eastern Canada is most threatend by drowning, which results from lack of sufficient buoyancy and protection, possibly aggravated by lack of bodily control through injury or, most likely, cold. The latter causes hypothermia which gradually reduces a person's ability to help himself as his core temperature drops until, when it reaches about 26°C, he dies, if he has not drowned first. It is concluded that, if a man is to stand a good chance of survival, his core temperature must not be allowed to drop below 35°C or at worst 33°C. It is concluded that the difference in time taken for a person's core temperature to reach this level in water temperature of 5°C and -1.8°C is immaterial, compared with the differences stemming from other variable factors such as:

- the person's mass to surface area ratio
- the amount of sub-cutaneous fat
- the person's physical fitness
- his general mental state.

It is assumed that survivors in the water would be rescued either by helicopter or by rescue vessels stationed in the vicinity. The response times which could be considered feasible are assessed and from them it is deduced that rescue from the water should be possible within four hours. Accordingly, it is

necessary to ensure that core temperatures of survivors are prevented from falling at more than 0.5C° per hour. It is recognised however that it may sometimes be impossible for those abandoning a unit in emergency to don a full survival suit. It is therefore prudent that provision of relatively cheap 'second line' 'throw away' suits at all abandonment points should be made and that these suits retain reduction of core temperature to 1C° per hour. If this were accepted, core temperature could have dropped to 33°C after four hours which, though causing deterioration in the condition of the wearer, should still leave him revivable.

Further physiological effects of immersion in cold air and water which are assessed are:

- cold shock
- freezing cold injuries
- non-freezing cold injuries
- cold incapacitation

The effects and prevention of the following are also considered:

- lack of nutrition
- inability to breath normal fresh air
- sea sickness
- burns
- body fluid loss

In considering the environmental factors which affect survival, those examined in Section 4 are examined plus sea temperatures, gales and storms. It is concluded that in typical severe storms, sea temperatures vary between -1.8°C and +14°C, that gales can last for between at most 12 and 48 hours and that storms last at most between 4 and 15 hours in different areas off the Eastern Canadian Coast.

The importance of training in survival and in particular education in the principles of survival is stressed.

The necessary communications needed by survivors during the survival phase and to assist in rescue are assessed, together with the requirements for location of survivors and their transfer to safety.

2.1.5 Criteria for Survival

The assessment of factors affecting survival contained in Section 6 is used to compile a list of criteria for survival systems in Section 7.

2.1.6 Assessment of Abandonment and Survival Systems

In Section 8, abandonment and survival systems are assessed against the criteria drawn up in Sections 5 and 7. The objective is to see whether existing systems and those under development can be expected to provide for safe abandonment and survival from MODUs, supply ships and helicopters in the Eastern Canadian Offshore Sector. Where they can not, current limitations which could cause this and, where environmental factors are concerned, the likely frequency of excessive conditions are assessed.

Because the number of different versions of the various types of equipment and systems available and under development for abandonment and survival is in many cases considerable, each one is not assessed against the criteria. Instead, the approach adopted in five main types of abandonment and survival systems is first discussed. These are:

- Evacuation by helicopter
- Dry transfer
- Rigid survival craft
- Inflatable survival craft
- Individual abandonment and survival

The alternative systems which may be, and often are, adopted in each type are described and the chief operating parameters of each are set out. These descriptions are used as a basis for assessment of each main system (and in the case of rigid survival craft, several different types of system) against the abandonment and survival criteria. The basis of the assessment is explained throughout and its results are summarised in two Tables (Tables 7 and 8). The meaning of the results of this assessment is then examined in detail and this leads to conclusions which are themselves summarised below.

2.2 CONCLUSIONS

2.2.1 Helicopter Evacuation

This provides the most satisfactory first line means of abandoning offshore units if sufficient response time is available (up to four hours); if the units are not listing beyond the limits of the helicopters involved; if fire or gas are not hazards and, perhaps most limiting of all, if visibility is sufficient. The frequency of the latter being the case varies from 97.5% of the time in one case in one month and area to as little as 61.7% of the time in another area and month. Visibility limitations can be overcome by fitting SAR designated helicopters with equipment which has already been developed for military use and is currently available fitted to some civilian helicopters.

Within what time period?

?

2.2.2 Dry Transfer

Several dry transfer systems have been designed and would, if effective, provide an excellent means of abandonment and survival. To be effective in the sort of conditions prevailing off Eastern Canada, they would need a dedicated receiving vessel and so, on financial grounds, do not lend themselves to use by isolated MODUs and are not designed for supply ships or helicopters.

2.2.3 Rigid Survival Craft

Current craft of this type depend for successful abandonment on their launching systems. They are unlikely to be launched successfully into wave heights over 8 metres or wind speeds over 50 knots. This limits their use off Eastern Canada to an appreciable degree. In particular, in areas off Newfoundland, the frequency of such conditions in the months of December to March varies from 25.3% to 46.2%. Such existing systems are also subject to limitations imposed by mechanical failures, particularly of release gear. Many of these limitations can be overcome by systems which are either available or under development. The free fall lifeboat system extends the wave conditions under which launch is safe to 9 metres (and probably, though not yet proved, to considerably more) and overcomes some other limitations.

The 'PROD' system, if proved, is likely to extend the wind and wave height conditions appreciably, maybe making launch possible under all normal environmental conditions in the area. It does not, however, cater for launch from the upper side of a heavily listing unit.

The 'Lifescape' system is expected to extend wave height limitations to about 12 metres.

In each of these systems, except possibly the 'Lifescape', it is advisable for survivors to wear full survival suits to protect themselves against the effects of cold.

No existing systems provide entirely satisfactory communications, location arrangements and means of transfer of survivors to safety while at sea. Suitable equipment is available to overcome the first two deficiencies but not the last.

2.2.4 Inflatable Survival Craft

These craft are looked upon as subsidiary systems following helicopter evacuation or rigid survival craft. They do not provide sure means of abandonment in poor weather conditions though, if abandonment can be achieved, they may well provide some protection in all conditions likely to be encountered in the area. They offer no protection against fire or irrespirable gas and to avoid the effects of cold, survivors must wear proper survival suits. They are ill equipped for communication, location and transfer of survivors to safety. In spite of these considerable limitations, however, they have a role to play as a 'last resort' system.

2.2.5 Individual Abandonment Systems

Survival suits are available which fulfill the physiological criteria for survival, though only a prototype hood to protect survivors from drowing has so far been produced. However, communications and transfer to safety present problems which are even more acute in the location of individual survivors.

Though special means exist to assist individuals to abandon MODUs, none have been found which would be effective in the adverse weather conditions found off Eastern Canada. Because individual abandonment is likely to be a last resort, probably taken as a unit sinks, the most important thing is to be protected by a suitable survival suit.

2.2.6 Helicopter Abandonment and Survival

Survivors from ditched helicopters rely on survival suits and life rafts. They are therefore subject to the same limitations as have been described for these types of equipment and so may not survive for more than about four hours in the waters off Eastern Canada unless the conditions make it possible to enter their life rafts successfully and at an early stage. The nature of survival suits used by those in helicopters is likely to differ from those used by people abandoning MODUs and supply ships, to reflect the different circumstances.

2.2.7 Supply Ships

Providing sufficient warning is available, abandonment of supply ships off Eastern Canada should be possible in the conditions normally found. Survival would be subject to the same limitations as in other situations discussed.

Currie, Coopers
& Lybrand

Management
Consultants

DRAFT

ROYAL COMMISSION ON THE OCEAN RANGER
MARINE DISASTER

ASSESSMENT OF THE NORMAL AND EMERGENCY COMMAND STRUCTURES RELATING TO DRILLING SYSTEMS FOR EASTERN CANADA OFFSHORE DRILLING OPERATIONS

May 25, 1984

Submitted to: Mr. R.G. Dyck,
Studies Manager

Submitted by: Mr. D.E. Smith
Mr. R. Jolliffe

EXECUTIVE SUMMARY

This section outlines the main elements of the full report. While we have attempted to include all of the essential points from the full report, full supportive evidence and elaboration will need to draw from the main body of the report.

I. PURPOSE OF THE STUDY

The main purpose of the study was:

- to identify and document the different types of command structures used in drilling systems off Canada's east coast:
- to evaluate the effectiveness of these structures for dealing with emergency incidents including a major fire on board, the loss of helicopter, the loss of support vessel, the loss of well control, and the loss of rig stability.
- to draw conclusions about the existing and possible alternative command structures.

II. DESCRIPTION OF COMMAND STRUCTURES FOR THE EAST COAST CANADIAN OFFSHORE DRILLING OPERATIONS

Since personnel safety was the focal point in our evaluation, the command structures which we reviewed embraced not only specific operator and drilling organizations, but also the links with helicopter and supply boat companies, C.O.G.L.A., N.L.P.D., the C.C.G. and S.&R. Thus, our intent was to evaluate the effectiveness of the onrig/shore-based relationship and their interactive effectiveness with these other support organizations under both normal, and emergency conditions.

SUMMARY OF COMMAND STRUCTURES BY RIG TYPE

COMMAND STRUCTURE / RIG TYPE	SENIOR PERSON IN CHARGE: DRILLING:	DRILLING ONLY WHILE STATIONERY ON HOLE	MARINE: (RIG MOVER) ONLY WHILE UNDERWAY	MARINE ONLY WHILE NOT DRILLING OR IN EMERGENCIES	MARINE AT ALL TIMES
JACKUPS	X		X		
DRILLSHIPS: D.P.					X
Anchored	X		X	X	
SEMI-SUBMERSIBLE "Norweigan"					X
"Norweigan Variation"		X	X	X	
"American" (Under U.S. Flag	X				

NOTE: There are some variations even within these categories. e.g. a D.P. Drill Ship may be under command of the senior drilling person, to all intents and purposes, while the ship is on the hole and drilling. Similarly, the "American" model varies to the extent that in Canada, U.S. flag vessels have captains on board but their real roles vary from virtual token responsibilities through to replicating the "Norweigan variation.

A. GEOGRAPHIC LOCATIONS HAVE A BEARING ON COMMAND STRUCTURES

Geographic location, dictates in part, the type of total system command structure. Remote locations such as the Davis Straits require virtual self-sufficiency by the operations for normal and emergency situations. In multi-operator areas, Operators have access to assistance from other operators and government search and rescue assistance. In order to achieve maximum benefits in multi operator areas from the other elements present, clearly defined policies and procedures are required. These have recently been enhanced in the form of a Joint Operator Alert Plan.

B. COMMON COMMAND STRUCTURES

We have identified a series of generic command structure models for each of the basic drill rig types. These are summarized in the chart on the facing page.

1. Jackup

- secured to the seabed by structural legs which support the platform
- in the drilling mode, it is commanded by a senior toolpusher (or rig superintendent).
- a barge master, usually with some marine experience and often responsible for safety, logistics and life boat operations, reports to the senior toolpusher.
- when under tow or in a non-drilling mode and location, command is formally handed over to a certified rig mover who has, as part of his certification, marine qualifications. While

undertow a licenced insurance representative monitors the move.

2. Drill Ships

- required by the Canada Shipping Act to have a Master Mariner with an unlimited foreign going certification in command.

- the command structures vary to some degree depending on whether the ship is anchored or dynamically positioned (D.P.) while drilling. The usual cases are:

  - dynamically positioned; the captain is in full command at all times;

  - anchored; the captain may or may not be in full command at all times. Often, the senior drilling person is in command while drilling. The captain assumes overall command when moving and in emergency situations.

3. Semi-Submersible

Semi-submersibles may be self-propelled and dynamically positioned or anchored, or they may not be fully self-propelled. The Canada Shipping Act classifies self-propelled semi-submersible as vessels and requires a marine captain with an unlimitd ticket on board. However, the Act does not clearly specify the role and extent of responsibilities of a captain under all conditions on a semi-submersible.

The following are the categories of command structures for semi-submersibles. They are summarized in the chart on the facing page.

a) Norweigan Model

Norway's regulations are clear and stringent. A marine captain must be in overall command of the rig at all times. In the event of a serious accident this, according to their law, permits them to single out the one person who has ultimate responsibility. There are examples of drilling contractors who ascribe to this model in Canadian waters. The drilling and marine persons may report to senior and separate drilling and marine persons on shore.

b) "Norweigan Variation"

The basic variation to the pure Norweigan structure is:

- Captain in command while underway and in emergency situations

- Captain responsible for safety of the personnel and the rig, and often supevises all non-drilling activities.

- senior drilling person in charge while driling but command is assumed by the captain as noted above.

- both usually report to a shore based operations superintendent. In some cases, they may report separately to marine and drilling managers on shore.

c. "American Model"

American rigs which operate under the U.S. flag (and especially when operating in U.S. waters) have a

straightforward command structure. It is probably based on a land-based drilling tradition but has been modified to U.S. Coast Guard requirements as follows:

- Senior drilling person is in command at all times;

- this person is required, in the U.S., to hold a limited marine ticket and a Column Stabilized Masters Ticket. These certifications provide specific marine and semi-submersible trianing. The tickets are not recognized in Canada nor can a non U.S. citizen obtain them.

- U.S. semi-submersibles which operate in Canada do have a master mariner (captain on board)

- in some cases, the captain has very little responsibility, and in practice the senior drilling person really is in command at all times, and

- some U.S. rigs have adopted the "Norweigan variation" noted above.

III. EXAMINATION OF INCIDENTS

We were asked to examine examples of two incidents for each of the five categories noted previously. Preferably these incidents should be drawn from Canadian East Coast operations.

Considerable difficulty was encountered in obtaining reliable and detailed incident reports. Additionally, only one incident from Canadian operations was found with respect to a blow-out situation, helicopter crash, and supply boat sinking. In these cases additional incident documentation was sought from United States operations, and, where these were obtained, an analysis was carried out.

The incident reprts underlined the importance of human error as a contributing cause to personal injuries and loss of life experienced. The reports further documented the need for a clear chain of command, for leadership abilities to provide firm direction during emergency situations, for well developed emergency or contingency plans, and for emergency drills to ensure that all crew members understand the actions required in emergency situations.

VI. EVALUATION OF COMMAND STRUCTURE EFFECTIVENESS

A summary of our evaluation of command structure effectiveness is provided in this section of the report. Command structure effectiveness was evaluated against eight criteria. The main report provides a discussion of each of the criteria.

A. COMPETENT AND TRAINED PEOPLE ARE REQUIRED

The first criterion for command structure effectiveness is the presence of a fully trained crew and staff complement.

1. Trained Marine Skills Are in Short Supply

- Training programs to develop marine skills for drilling personnel are not well developed in Canada.

- Interviews indicate that trained and experienced deck officers with drilling experience are in short supply world wide.

- Typical Canadian marine training for conventional vessels is not comprehensive enough to apply to twin hulled semi-submersibles or even drill ships, particularly in the areas of ballasting and the inter-relationship with drilling operations.

- C.O.G.L.A. and provincial Canadian content guidelines and regulations are a dissausive factor for foreign crew to come to Canada, and

- The industry is consequently forced to spend more on training and place less experienced people than desired in senior positions.

2. Back-Ups for Key Resources are also in Short Supply

- The gap in experience and training between Captains and other deck officers and ballast control operators is pronounced.

3. Recognized Training Qualifications and Certifications do not Exist for Several Positions

- No certification program for rig deck officers exists in Canada.

- The U.S. has a Columnized Masters Certification Ticket but this is available only to U.S. citizens in the United States.

- Although the drilling Contractors have a planned program assembled, no standard ballast control training and certification program is in place. This is also true for rig movers and barge masters.

- Two schools in St. John's and Halifax provide government and industry acceptable survival training. All rig crews are being processed through these systems.

- Planning for a standardized life boat captain training program is underway.

4. Government Regulations/Guidelines Do not Fully Recognize the Specific Requirements of the Industry

- The Canada Shipping Act requires a captain on board self-propelled rigs which are deemed to be vessels. The Act does not spell out specific training required or recognize the full differences between conventional vessels and rigs.

- C.O.G.L.A. guidelines indicate that a rig should be commanded by a person who has experience in drilling but specific qualifications are not spelled out.

B. A STRONG UNIFIED STRUCTURE MUST EXIST

1. The Degree of Unity of Command is Partially a Function of the Type of Rig

a) Jack-ups are commanded totally by a drilling person when drilling and by a rig mover when off the hole or in port. The command structure is clear and unambiguous.

b) Drill Ships have a clear structure in most cases, with a marine captain in command at all times. In some cases, there is a duality or sharing of command between the Captain and drilling superintendent. In the latter case, response plans do not clearly state alert conditions which trigger overall command by the Captain.

c) Semi-submersibles have a variety of command structures. When there is a shared command situation the response plans do not usually specify clearly conditions or stages when total command is assumed by the Captain.

The shared command systems could lead to potential confusion in absence of clear conditions specifying command and of an understanding of this by the crew. The North Atlantic dictates the need for sound marine experience and skills. The marine skills and managerial attitudes must blend with those of the drilling operation.

2. Knowledge and Mutual Respect are Key Contributors to Unity of Command

Mutual respect between drilling and marine elements and the welding of these different skills into a united team, can only be achieved by having these individuals work together over a period of time so that an appreciation of each other's skills is obtained. This will foster effective command on board.

3. Divided or Shared Command Can Weaken Response Effectiveness

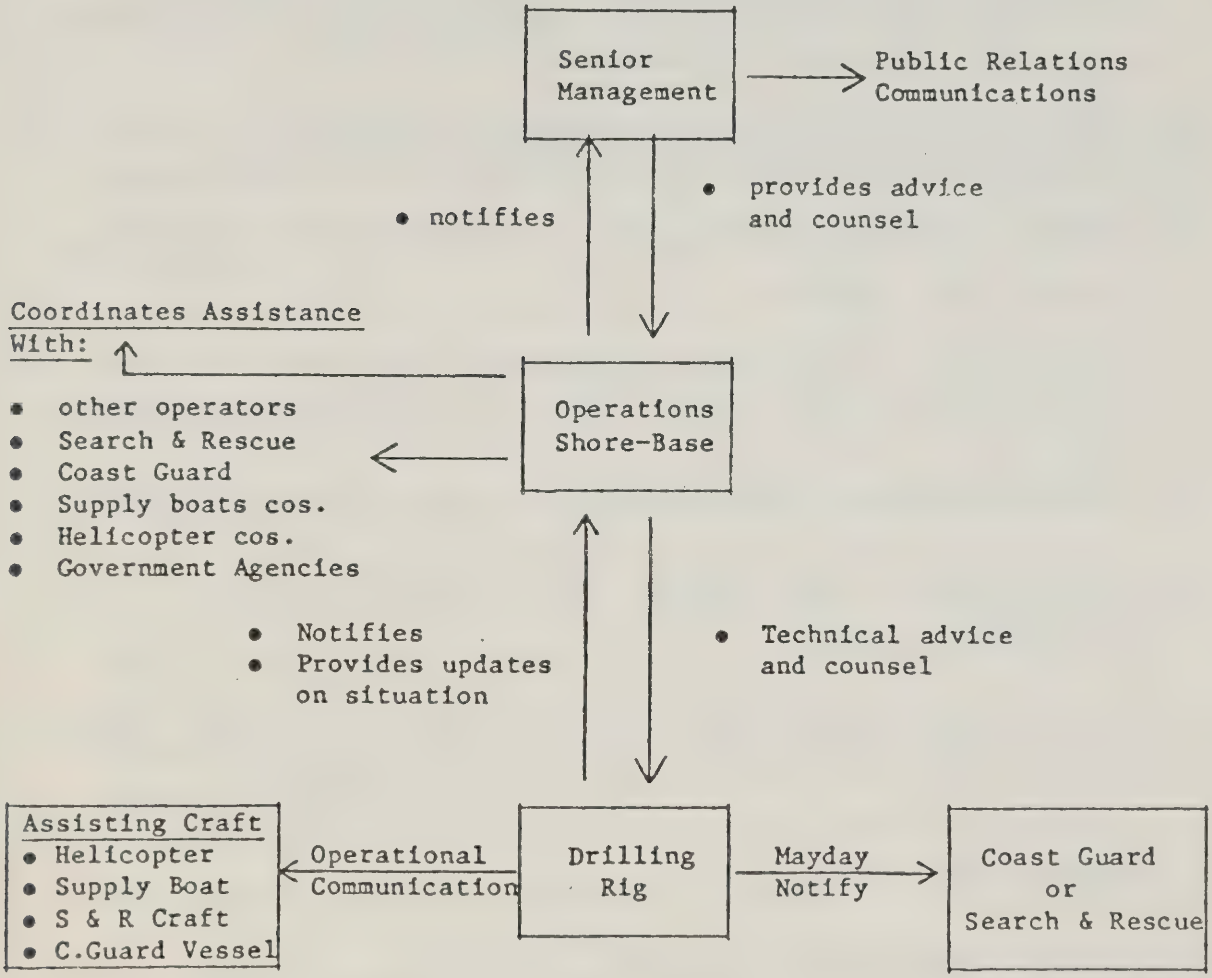
It is our observation that if a marine captain is unfamiliar with drilling, and/or is a weak manager, the senior drilling person will be (and seem to be by the crew) de facto commander in all situations. This could lead to conflict detrimental to crew safety.

The converse is also true. It must also be recognized, however, that Canadian environmental conditions require dedicated attention to both the drilling and marine elements. Therefore shared command structures shuld be clearly designed and unequivocal.

4. Command Structure Documentation Could be Improved

To fully support cases and where command transfers from the drilling to the marine element in emergency conditions, response

MODEL OF EMERGENCY COMMUNICATION PROCESS



plans and procedures should clearly outline the trigger points. A few plans were weak in this area, particularly:

- in not clearly citing back-ups to senior personnel;
- confused reporting lines;
- charts which state captain's responsibilities that are greater than in practical, operating fact.

C. COMMAND STRUCTURES SHOULD MOVE TO SUCCESSIVE ALERT STAGES

The majority of response plans indicate alert stages. However, some weaknesses are apparent:

- alert stages in shore based offices are not clear,
- heavy weather conditions for an on-board alert not stated,
- conditions to put Search and Rescue on active alert not indicated.

D. A STRONG SENSE OF ORGANIZATIONAL UNITY - TEAMWORK ENHANCES EFFECTIVENESS

Organizational effectiveness cannot be legislated. It takes time for organizational cohesiveness to be built up. Rapid moves to "Canadianize" the industry could have a negative effect on organizational unity.

E. EFFECTIVE COMMUNCIATIONS PROCESSES ARE REQUIRED

The model on the facing page outlines a simple communications process. Our observations of common aspects of response plans were as follows:

- overly complex communciations patterns for the rig commander.

- base operations to communicate directly with on-scene helicopters and supply boats instead of operational communications direct from the Rig commander.
- long lines of communication up the organization's hierarchy;
- communications from rig not clearly centralized through the base emergency command centre.

Generally, documented communications patterns attempted to cover all eventualities and to adhere to various government guidelines without adhering to the principles of short communication lines to deal with emergencies.

F. EFFECTIVE PROCEDURES TO COORDINATE THE EFFORTS OF ALL ELEMENTS IN MULTI-OPERATOR AREAS

A mutual aid pact amongst operators has been informally in place for some time. The related policies, procedures, and systems have recently been further developed and documented. The plan serves to significantly enhance rescue operations. In addition, flight following, iceberg and weather tracking systems are in place. We believe that more work, however, is necessary to ensure C.C.G. and S&R are fully conversant with the plan.

G. EXERCISE OF THE COMMAND STRUCTURE IS REQUIRED

A variety of contractor specific on-board drills and multi-operator government agency drills have been conducted. On board drills have generally ensured that rig personnel are familiar with their duties in emergency situations. Further enhancements would however be useful including:

- suprise drills to simulate actual conditions.

- designated individuals should act as observers to provide feedback on drill effectiveness. Formal debriefing sessions to evaluate effectiveness should also be instituted.
- equipment and evacuation systems should be enhanced so that full evacuation drills can be safely carried out.
- drills should be designed to test the preparedness of back-up personnel.
- further exercises should be conducted on a regular basis to ensure adequate familarity by Search and Rescue and the Coast Guard with drilling operations.

H. DECISION MAKING MUST BE CLOSE TO THE SCENE OF THE ACTION

Some response plans imply that key decisions are to be made by shore based managers. However, all officials in the industry whom we interviewed agreed that decisions regarding rig operations, rescue, evacuation or assistance needs should be made at the scene.

V. RECOMMENDATIONS FOR IMPROVED COMMAND STRUCTURE EFFECTIVENESS

A. THE SUPPLY OF, AND METHODS FOR TRAINING, QUALIFIED PEOPLE SHOULD BE ENHANCED

The following actions should be implemented:

1. Evaluate Canadian marine training and develop improvements to address offshore drilling needs.

2. Recognize offshore drilling as a subset or specialty section of Canadian marine training and adopt appropriate guidelines/regulations.

3. Implement standardized ballast control training.

4. Continue marine survival training;

5. Develop appropriate standards for offshore drilling in cooperation with the C.C.G.

B. EXISTING REGULATIONS SHOULD BE MADE INDUSTRY SPECIFIC

Update standards and qualifications to address the industry requirements.

C. DEVELOP STANDARDS FOR UNITY OF COMMAND

Some command structues indicate a unity of command, at least in theory, e.g. on jack-ups and some drill ships and semi-submersibles. Others show a shared responsibility with the captain assuming responsibility in emergencies.

On drill ships and semis, there is a clear need for both marine and drilling expertise in Canada's waters. The development of an adequate supply of fully qualified rig commanders who have skills in both the marine and drilling functions will take several years to achieve. Therefore, the propensity to continue with shared responsibilities in some organizations will likely continue to exist. Certain conditions would need to be met as follows:

- assign real, not paper, responsibilities to marine captains including supervision of all safety features and certain on-rig support services such as general rig maintenance, etc.

- assign supreme command to the Captain in emergency situations and when underway;

- define clear guidelines which say when command should be under the Captain.

- ensure emergency response plans indicate emergency alert conditions which trigger the captain's assumption of command, and

- ensure organization charts developed and adopted by the industry are straightforward and not confused with combinations of duplicate solid or dotted line relationships.

D. COMMAND STRUCTURE ALERT STAGE DOCUMENTATION SHULD BE FURTHER DEVELOPED

1. Operator/Contractor emergency response plans should describe conditions of successive alert for shore based operation.

2. Plans should indicate conditions under which the rig should call S&R and/or C.C.G..

3. An understanding by all elements, including S&R and C.C.G. of the pertinent aspects of the response plans should be confirmed.

4. Industry-wide alert stages for each of the five emergencies addressed in this study should be adopted in the response plans.

E. DRILLING UNIT TEAMWORK AND COHESIVENESS SHOULD BE ENHANCED

The following should be provided to supervisory personnel across the industry:

- leadership and interpersonal skills training.

- training programs which foster understanding of the technicalities and attitudes and value systems in marine and drilling staff of each other's backgrounds.

In addition, Canadianization programs should move slowly so not to jeopardize teamwork and safety. We suggest that a high ratio of fully

to newly trained staff be maintained at non "officer" levels at all times.

F. COMMUNICATIONS PROCESSES SHOULD BE STANDARDIZED

A basic communication pattern for emergencies should be:

- rig commander (or delegate) notifies S&R, C.C.G., and operator shore base of an alert or actual emergency,

- rig commander talks directly with helicopter and supply boat captains,

- all communications are centralized in Operator's emergency command centre,

- adopt an industry wide standard set of alert codes and ensure that the appropriate responses are understood by all elements.

G. EXERCISE OF THE WIDER COMMAND STRUCTURE SHOULD BE MORE FREQUENTLY UNDERTAKEN

The following should be adopted across the industry:

- drills to test knowledge and effectiveness of back-up positions

- ensure all elements, through multi-operator "paper" exercises test and confirm each organization's knowledge of their roles, communication systems, responses and logistical requirements;

- involve C.C.G. and S&R in exercises once per year for each rig in order to test their systems and enhance their knowledge of drilling operations.

- joint exercises involving new rigs in the drilling area should be conducted as soon as possible.

Much progress has already been realized in recognizing the importance of command structure effectiveness to the offshore drilling industry. Many improvements have already been implemented. **We view the staffing and training of qualified resources and the adoption of recognized certification programs as the most critical element in improving command structure effectiveness.**

DRAFT

EXCERPTS FROM

SAFETY IN THE DESIGN, CONSTRUCTION,
AND OPERATION OF
OFFSHORE OIL AND GAS INSTALLATIONS

A COMPARATIVE ANALYSIS (SUMMARY) OF THE
REGULATORY STRUCTURES OF NORWAY, CANADA,
UNITED STATES AND THE UNITED KINGDOM

CHAPTER ONE

INTRODUCTION

In the last decade there has been an unprecedented increase in the search for offshore oil and gas. Encouraged by rising world demand for hydrocarbon resources and facilitated by an increasingly sophisticated technology, this search has expanded to include some of the most hostile areas of the world's oceans. Drilling operations are now routinely carried out in deep waters where 50 foot seas and passing icebergs are a common occurrence. Here the cowboy roughneck has, by necessity, entered the domain of the sailor and set to sea on a structure at the cutting edge of marine and drilling technology, creating an unfamiliar environment for roughneck and sailor alike. Here, offshore, the oil industry, historically unregulated with respect to operations and training of personnel, meets the shipping industry with its long history of strict regulation and concern over safety yet slow acceptance of change.

Although this proliferation of offshore activity has been accompanied by limited national legislation, comprehensive safety regulations covering all aspects of the design, construction and operation of offshore installations are generally still needed. The importance of constant evaluation of the effectiveness of safety regulations in actual practice has been painfully demonstrated by the catastrophic losses of the Alexander L. Kielland in March 1980 and the Ocean Ranger in

February 1982.

It must be realized that Canada is on the threshold of an all-out effort to exploit offshore resources. It would be as tragic as the Ocean Ranger disaster itself if Canada failed to take maximum advantage of the experiences and mistakes of others who have preceded us.

The purpose of this study is to examine the structure, approach and mechanisms of promulgated safety regulations governing the design, construction and operation of offshore installations in a selection of countries actively involved in offshore exploration development and production.

Chapter Two briefly considers some of the international legal issues arising from offshore hydrocarbon activities. These issues are very complex and the topic is worthy of further study. Chapter Three addresses in general the subject of legislative policy. Chapters Four through Seven summarize the structure approaches and mechanisms of offshore safety regulations in Norway, the United States, the United Kingdom and Canada. Chapter Eight is an overview section. It highlights the important differences between the approaches of the various jurisdictions and surveys a list of modes and methods that were identified during the comparative analysis.

The following four chapters outline, in considerable detail, the approach to regulation of safety in the design, construction, and operation of offshore installations by Norway, Canada, the United States, and the United Kingdom. What is presented here is a summary of the basic approach used by each of these countries.

CHAPTER FOUR

NORWAY

Although primary responsibility for the safety of offshore installations is vested in the Department of Local Government and Labour, it has delegated its authority to various state agencies with the Maritime Directorate and the Norwegian Petroleum Directorate retaining a coordinating role for safety on mobile and fixed installations respectively. While extensive regulations establish both functional requirements and specific standards of safety for installations, equipment, personnel, and operations, the government exercises its control through a system designed to place the responsibility for compliance on the operator or licensee. The internal control system establishes a comprehensive framework for monitoring corporate quality assurance systems through documentation evaluation and spot checks. In order to ensure the efficient operation of such a system, continuous communications between government authorities and individual operators is encouraged to maximize understanding and to minimize

misinterpretations of regulations and guidelines. While the scope of the Norwegian regulatory system is extensive compared to most other jurisdictions, individual regulations have been designed to incorporate flexibility in an effort to ensure that changes in technology and operational procedures, equipment, etc., can be adopted in individual cases, reflecting the conditions specific to each installation's operation.

CHAPTER FIVE

UNITED STATES

At least eight bureau-level agencies administer the numerous requirements that are related to safety of offshore drilling operations. Of these, the Department of the Interior (through the Geological Survey and the Bureau of Land Management) and the Department of Transportation (through the Coast Guard) have primary authority over safety in the design, construction, and operation of offshore oil and gas installations. This multi-agency jurisdiction has resulted in an extremely complex and, in many cases, duplicative regulatory system. This problem of overlapping jurisdiction has been partially solved by the use of memorandums of understanding between agencies and departments.

There are many mechanisms employed by the regulatory agencies in fulfilling their mandates. These range from broad-brush enuncia-

tions of general policy to the imposition of extremely detailed design, equipment, and procedural requirements. In some areas, such as training and certification of personnel, the US approach has favoured leaving the details up to the companies themselves, confining government regulations to the area of equipment design and procedural guidelines. In other areas, such as the design, certification, and installation of equipment for fire prevention, well control, and workplace safety, the US regulations are extremely detailed and often incorporate industry standards and guidelines. Increased demand on Coast Guard inspection personnel, increasingly complex technologies and a current desire to minimize government involvement in the private sector has resulted in widespread use of voluntary standards and the increased involvement of classification and professional societies in the regulatory process.

CHAPTER SIX

UNITED KINGDOM

Responsibility for offshore safety of oil and gas installations in the UK rests with the company. Regulations tend to be drafted in general terms, giving the company wide latitude in their practical application with the assistance of non-mandatory measures such as Guidance Notes. The role of certifying authorities in inspection and survey functions is significant and is supplemented by the in-house government inspection capacity which has been

developed over the years. Additionally, the UK system emphasizes the use of external organizations, such as UKOOA, to assess and indicate the need for technical standards and regulations in order to reduce the costs to the Department of Energy and to ensure that realistic and up-to-date technologies are utilized in the offshore.

CHAPTER SEVEN

CANADA

The Canada Oil and Gas Lands Administration (COGLA) headed by the Chief Conservation Officer has the primary jurisdiction over offshore drilling operations. COGLA, through the Canada Oil and Gas Drilling Regulations and through close cooperation with the Canadian Coast Guard, regulates the safety of these operations. The primary mechanism employed by COGLA is the application-permit process, which requires that the operator submit for approval detailed information on all proposed activities and associated equipment. This procedure must be followed at each stage of any offshore drilling programme. Though the Canadian regulatory system depends heavily on the application-permit process, some use is made of detailed equipment and procedure requirements, as well as incorporation by reference of a number of accepted standards. The Canadian authorities also require information concerning drilling operations to be recorded and submitted on a regulary basis. Through this mechanism the Chief Conservation Officer is

constantly in touch with the day-to-day operations and safety record on each drilling unit.

NEWFOUNDLAND

With respect to offshore safety, the Newfoundland regulatory regime uses mechanisms and approaches similar to those employed by the Canadian Federal administration. The recently promulgated Design, Construction, and Survey Regulations and the Drilling Regulations, and the non-promulgated Winter Drilling Guidelines, however, reflect concerns arising directly from the loss of the OCEAN RANGER. At present, there is no Federal equivalent to the Design and Construction Regulations or to Newfoundland's requirement that all permanent employees obtain a Maritime Emergency Duties Certificate.

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RECOMMENDATION

With respect to offshore safety, the Newfoundland regulatory regime uses mechanisms and approaches similar to those employed by the Canadian Federal Administration. The recently promulgated Design, Construction, and Survey Regulations and the Drilling Regulations, and the non-promulgated Winter Drilling Guidelines, however, reflect concerns arising directly from the loss of the OCEAN RANGER. At present, there is no Federal equivalent to the Design and Construction Regulations to the Newfoundland requirement that all permanent employees obtain a Marine Emergency Duties Certificate.